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INSPECTION COSTS FOR A MULTILATERAL CHEMICAL WEAPONS CONVENTION

An Analytical Framework and Preliminary Estimates

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The draft Chemical Weapons Convention (CWC) now being negotiated at the forty-nation Conference on Disarmament is a complex disarmament convention to both eliminate chemical weapons and to deter further production. Achieving these goals will require an extensive verification regime involving a variety of inspections, visits, and extended on-site presence. Planning for such a regime requires an understanding of the level of effort that will be required and the costs that may be incurred. This paper examines the draft Convention, develops an analytical framework for costing the monitoring activities associated with the CWC, and provides preliminary cost estimates under a variety of assumptions.

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PREFACE

This paper was prepared by the Institute for Defense Analyses (IDA) for the Office of the Assistant to the Secretary of Defense (Atomic Energy) under Contract No. MDA903-89C-0003, Task T-V6-735, Chemical Weapons Agreements Verification Resource Requirements.

The objective of the study is to develop a framework for estimating the costs of verification of potential chemical weapons treaties and to provide initial quantitative estimates of those costs.

This paper was reviewed by Mr. Bas ter Haar of the Netherlands Ministry of Foreign Affairs, and Mr. Paul Goree of IDA's Cost Analysis Research Division.

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A. TASK DESCRIPTION AND RATIONALE

The Institute for Defense Analyses was tasked by the Office of the Assistant Secretary of Defense (Atomic Energy) to develop a framework for estimating verification costs and to provide initial cost estimates to the United States under a multilateral Chemical Weapons Convention. This paper documents the results of that task and demonstrates the method used to estimate on-site inspection costs.

The draft Chemical Weapons Convention now under negotiation at the 40-nation UN Conference on Disarmament is a comprehensive disarmament agreement. The prototype Convention is designed both to eliminate chemical weapons and to detect and thereby deter any attempts thereafter to produce chemical weapons.

An International Organization will be established by State Parties to the Convention, and under that body a Technical Secretariat will be entrusted to implement the verification and monitoring functions. An International Inspectorate, acting as a unit under the supervision of the Technical Secretariat, will then carry out an extensive on-site verification regime.

State Parties are obligated under the Convention to declare chemical weapon stockpiles, chemical weapons related facilities, and facilities in the chemical industry that are relevant for purposes of chemical weapons production. During the first 10 years after the Convention enters into force, on-site inspections will be conducted at storage, destruction, and chemical weapon production facilities to confirm the accuracy of reported stockpiles and to monitor the elimination of chemical weapons and related weapon production facilities. For the lifetime of the Convention, on-site inspections will be carried out at industrial facilities to confirm that chemical weapon precursors that are produced or used for commercial applications are not diverted to the production of chemical warfare agents.

Under the Convention, costs will accrue to establish and maintain the International Organization responsible for implementing the verification measures related to on-site inspections, installation and maintenance of monitoring equipment, sampling and analysis,

and review of data. State Parties to the Convention will fund the International Organization, and as a State Party the United States will bear some fraction of those costs.

The US will incur additional costs beyond the international contribution to cover inspection team escorts and additional security and protective measures. The United States also will have to fund its own domestic National Authority, which will demonstrate US compliance with the Convention, compile national data, and interact with the International Organization.

The draft status of the Convention precludes definitive estimates of all US costs to implement and comply with a final Convention. Many aspects of the Convention which are crucial to final costs will be added to complete treaty text as negotiations continue. Yet a firmer understanding now of required resources will support implementation planning at the Department of Defense.

Estimates of the costs to implement on-site inspections help to approximate the resources needed to match the requirements of current language in the draft Convention. Initial estimates from a draft Convention may differ from final outcomes, but they provide a means to evaluate options and compare alternatives. Cost profiles presented in this paper show the difference in the costs for inspection teams composed of 6 and 10 inspectors and the effect of increasing or decreasing the frequency of inspections.

B. APPROACH

The cost structure developed in this paper addresses two areas of uncertainty about a verification regime for the Chemical Weapons Convention. First, since many areas of the Convention have not been elaborated, an inspection framework was constructed to describe on-site activities under titled inspections or visits. The language of the evolving Convention, called the "Rolling Text," was followed, and the working papers submitted by delegations to the Ad Hoc Committee were integrated in this framework to forecast what a final Convention might look like. (Chapter I of this document discusses the framework in detail.) In the second area of uncertainty, estimates were made as "place-holders" for resources required to implement verification provisions. Estimates were made for the yet unknown number of declared facilities, for the duration and frequency of inspection, and the size of the inspection teams (Chapter II). These estimates were developed from discussions with officials representing national governments and industry and supplemented by reports from National Trial Inspections and other sources of expert opinion. Third, resource estimates were combined with the inspection framework to

generate a base case cost example (Chapter III). The base case was then varied, by changing the resource estimates, to show alternative cost profiles for eight additional cases. Finally, US government costs were derived by assuming a percentage contribution from the US to the International Organization and adding to this total the costs of providing escorts for inspections in the United States. Chapter IV discusses the limitations of the analysis and notes several observations which follow from the analysis and from discussions with individuals in the chemical weapons and arms control community.

The draft Convention portrays verification objectives under the broad heading of "systematic international on-site verification through on-site verification and monitoring." Related on-site inspection activities, and inspection titles, are not identified consistently throughout the Convention. Procedures defining "systematic verification" and the Protocol for the conduct of inspections require substantial elaboration.

The inspection framework is thus drawn as a composite of several sources. For costing purposes, on-site inspection activities are described as discrete events to identify expenses related to implementing "systematic verification." On-site inspections and on-site visits are given titles that match the purpose given for verification or an aim stated in the Convention. Some of the inspection titles adopted in this paper to categorize inspection activities, i.e., installation visit, closure inspection, site elimination inspection, elimination inspection, and close-out inspection are not listed as titles by the draft Convention text but are nonetheless consistent with objectives depicted in the treaty.

C. TYPICAL RESULTS

Typical results obtained in this paper are displayed in Figure ES-1, which compares annual costs for the international organization to the cost for the US over 15 years following entry into force (EIF) of the CWC. The inspection-related activities for the number of declared facilities assumed in this paper will cost the International Organization on the order of $800 million over 15 years. As noted earlier, the United States would be responsible for a portion of that overall cost and for all costs associated with escorts for inspections at US facilities, a total somewhat below $400 million.[1] Chapter III presents a spectrum of results for alternative assumptions and the sensitivities of the costs to certain key factors.

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[1] All costs in this paper can be taken to be in constant 1990 dollars.

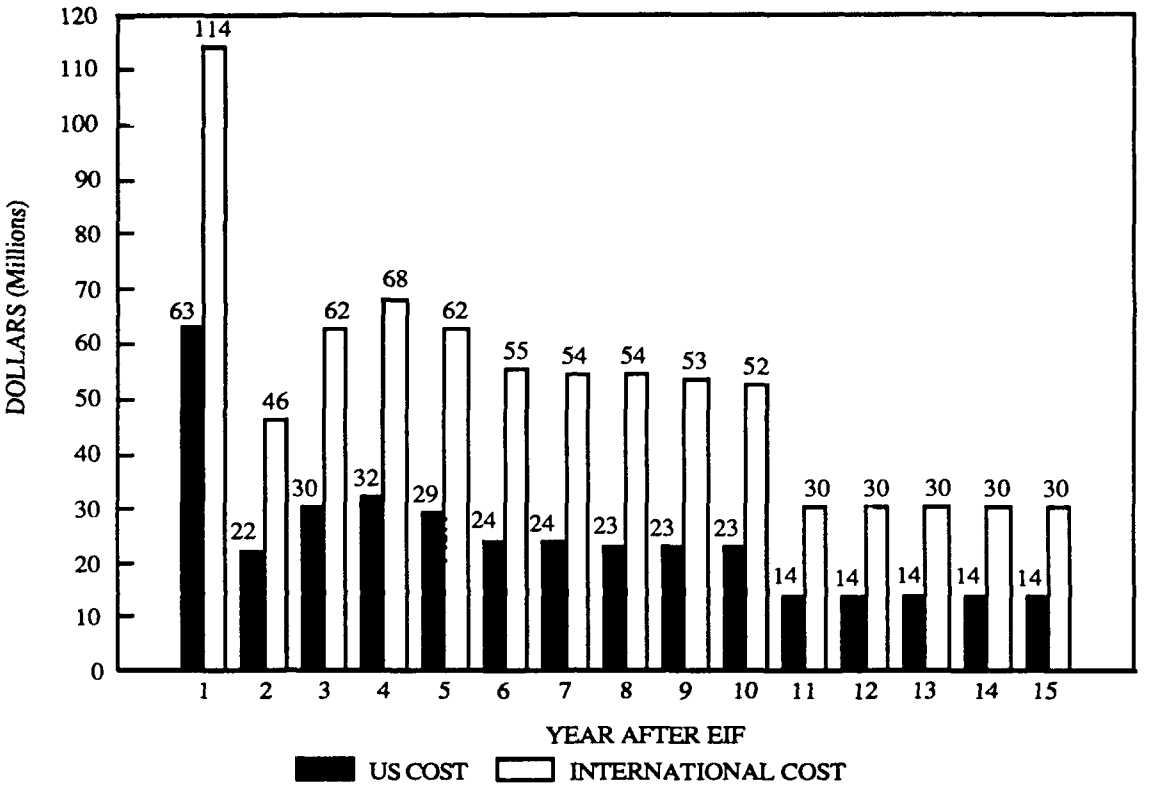

Figure ES-1. Cost Profiles Base Case: US vs International Organization

D. REQUEST FOR COMMENTS

This paper is intended to initiate expanded analysis of the CWC. The authors welcome comments, criticism and related information. Please forward these to Dr. J. H. Grotte, Institute for Defense Analyses, 1801 N. Beauregard Street, Alexandria, VA 22311, USA.

I. ON-SITE INSPECTION FRAMEWORK

A. INTRODUCTION

This chapter presents an inspection framework that was developed to estimate verification costs associated with a multilateral Chemical Weapons Convention (CWC) now being negotiated.[1] The Convention is designed both to eliminate chemical weapons and to detect and thereby deter any attempts thereafter to produce chemical weapons.

An International Organization will be established by State Parties to the Convention, and under that body a Technical Secretariat will be entrusted to implement the verification and monitoring functions. An International Inspectorate, acting as a unit under the supervision of the Technical Secretariat, will then carry out an extensive on-site verification regime. That regime will entail a number of on-site inspections and visits to storage, destruction, chemical weapon production and relevant industrial chemical facilities for the purpose of verifying the State Parties' compliance with the Convention and separate facility agreements.

The framework for estimating verification costs was constructed by drawing from working documents of the Ad Hoc Committee negotiating the Convention and and supplemented by other sources. Where possible, the language of the evolving Convention, called the"Rolling Text," was followed, but the framework structures verification objectives for costing purposes so that estimates may be used to demonstrate resource requirements to implement the Convention.

Judgments are adopted in the framework where aspects of a final verification regime are not yet known. The draft Convention is inconclusive on key implementation issues that will drive costs. Moreover, total costs ultimately will depend on the number of facilities monitored by the International Organization.

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[1] The latest version of the draft Chemical Weapons Convention, also called the Rolling Text, is in the Conference on Disarmament Document, CD/961, 1 February 1990. The Rolling Text in Appendix I of CD/961 comprises 20 Articles and 8 Annexes. Papers included in Appendix II represent working discussions at the Conference for later inclusion in the draft Convention.

A final Convention will address the size of inspection teams[2] and will elaborate guidelines[3] for determining the frequency and number of inspections. Further, on-site inspections will be conducted in conformance with individual inspection plans and detailed measures developed as "facility agreements."[4] These facility agreements will be negotiated between the International Organization[5] and the State Party after the Convention enters into force and will take into account the unique characteristics of each facility. International Inspectors will then follow the facility agreements regarding the rights of the inspected facility, access for inspectors, duration and intensity of inspections, and sample and analysis procedures.[6] The agreement also will specify whether on-site instruments will be used to monitor a facility.

The terms of a final Convention and the criteria mentioned above will determine the workload of the Organization and the required size of the International Inspectorate. The inspection framework addresses the incomplete provisions of a final Convention by structuring verification objectives as on-site activities. The resource base to support the inspection framework is then derived from estimates for the undetermined factors and calculated in a cost model. Resource requirements thus determined demonstrate the "on-site verification and monitoring" depicted in the Convention.

Verification objectives are linked to facilities inspections and visits and are described in three categories of activities: On-site Inspections (OSI), On-Site Visits (OSV), and verification by the Permanent Presence (PP) of inspectors. As the modalities and procedures for on-site verification are being considered, representative inspection team activities are presented to illustrate stated verification aims or a purpose given in the Convention for on-site verification.[7] Where the Convention gives the aim as "verifying the

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2 Team size is currently addressed in the draft CWC by the following language. "[An inspection team conducting routine inspections pursuant to Articles IV, V, VI, shall include no more than (xx) inspectors and (xx) inspection assistants.]" Protocol on Inspections, page 136.

3 CD/961 Annex to Article IV, Section II, paragraph 5(f)(ii) "(The guidelines for determining the frequency of systematic on-site inspections are to be elaborated.)" page 71.

4 " 'Facility Agreement' means an agreement between a State Party and the Organization relating to a specific facility subject to routine inspection." CD/961 Protocol on Inspection Procedures, page 117. Facility agreements will be based on a generally applicable models. CD/961 now includes draft models for storage facilities, Schedule 1 and Schedule 2 facilities, although additional work is required on these model agreements.

5 CD/961 Article VIII, would establish the "Organization for the Prohibition of Chemical Weapons". "International Authority" is also used to refer to the International Organization.

6 CD/961 Annex on the Protection of Confidential Information, page 61.

7 Inspection activities are developed from a composite of sources to describe inspection team procedures. Our objective in this framework is to identify the cost elements of implementing the on-site

declaration," the framework describes inspector tasks to confirm the information in the data declaration on the types and numbers of chemical weapons reported for the facility.

Resource estimates are used to approximate the level of effort required for each category of on-site activity for every type of facility monitored by the International Organization. For each on-site inspection or visit, the size of inspection teams, the duration of the inspection or visit, and additional time for team preparation and recovery are represented as estimates. Further estimates are made for the frequency of inspections and the number of facilities worldwide. These estimates are then varied in eight different cases to give illustrative costs associated with increasing or decreasing the frequency or number of inspections and the size of inspection teams.

In the current Convention, the titles Initial Inspection, Initial Visit, Permanent Presence, and Routine and Periodic Inspection are used. Additional verification is acknowledged under the broad heading of "systematic international on-site verification through on-site verification and monitoring."

Titles for on-site inspections and visits are adopted in this framework to categorize the objectives of systematic verification and, furthermore, to identify specific events for costing purposes. For while the Convention recognizes certain on-site activities, such as equipment installation, "inspector presence to witness destruction," and final on-site certification of the destruction of chemical weapons, these objectives are not specifically titled as inspections. This inspection framework follows the stated objective by adopting the titles Installation Visit, Closure Inspection, Site Elimination Inspection, Elimination Inspection, and Close-out Inspection. A final category of on-site verification, Ad Hoc Inspection, is used as the title for the additional regime proposed by some delegations to the Ad Hoc Committee of the Conference on Disarmament.

Inspection team activities are described for all on-site inspections and visits at facilities declared under Articles IV, V, and VI.

Initial Inspections and **Initial Visits** are conducted at declared facilities to verify the accuracy of each State Party's declaration and to obtain planning information for the design and conclusion of facility agreements.[8] **Installation On-Site Visits** are

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verification objectives. Thus, this paper focuses on the aims or purposes listed in the draft CWC and does not discuss technical aspects related to how the objectives will be achieved.

8 Two different terms are used in the draft CWC to refer to similar activities for the first on-site presence: initial on-site inspection and initial visit. "Initial Inspection" is used in The Protocol on Inspections,

carried out to initiate the verification measures outlined in the facility agreement for each facility by installing monitoring equipment. Alternatively, systematic verification is initiated when directed by the Technical Secretariat to establish a **Permanent Presence** of inspectors to monitor facilities on a continuous basis.

During the 10-year destruction period, several types of **Routine Inspections** will be conducted on a routine[9] *or* periodic basis to exercise agreed verification measures at all declared facilities dealing with storage, destruction, chemical weapon production and related activities, and Schedule 1 and Schedule 2 chemicals. (Schedule 1 chemicals primarily include known and tested chemical warfare agents or chemicals closely related to the known agent; they have limited commercial application. Schedule 2 chemicals are precursors to chemicals found in Schedule 1 and are produced substantially in commercial industry.) Routine inspections will reoccur throughout the destruction period at all declared facilities and thereafter at Schedule 1 and Schedule 2 chemical facilities to continue monitoring permitted activities.

The Technical Secretariat will select facilities for inspection on a *routine* basis using a selection process that will not allow sites to predict exactly when they will be inspected. The Technical Secretariat also will direct, on a *periodic* basis, on-site inspections to coincide with planned elimination activities to verify that the facility is complying with the detailed obligations and plans set forth for each facility. On-site verification at destruction facilities will take place during Active Destruction Periods by the Permanent Presence of inspectors. At chemical weapon production and related facilities, **Closure Inspections**,

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which was added only in January 1990 to Appendix I. "Initial Visit" is still found in the draft text. We retain the use of initial visit for the first on-site presence at Schedule 2 facilities. Initial visits were conducted at commercial facilities during National Trial Inspections prior to actual inspections to familiarize the inspection team with the facility.

9 As discussed in the proceedings of the Conference on Disarmament, routine on-site verification has two meanings: routine implies both a TYPE of inspection and a reoccurring EVENT. First, "Routine Inspection" is used to contrast routine inspection from proposed on-site verification by Challenge On-Site Inspection or Ad Hoc verification. Under this meaning, routine inspection is a type of inspection that takes place at all declared facilities. See CD/961, page 119: " 'Routine Inspections' means the systematic, on-site inspection [subsequent to initial inspections] of facilities declared pursuant to Articles IV, V, VI and the Annexes to those Articles." Second, the term "routine basis" is used to refer to the fact that these inspections reoccur in a regular manner by an unpredictable selection method. See CD/961, page 106: "Each facility notified to the Technical Secretariat under this Annex shall be subject to systematic international on-site verification on a routine basis." This usage then contrasts to the term "periodic on-site inspection." (CD/961, page 19), which is used to denote repeated on-site verification at irregular intervals at chemical weapon production facilities. By illustration this implies that chemical weapon production facilities will be subject to Routine Inspections which will occur on a periodic basis according to verification requirements designed for the facility.

Site Elimination Inspections and **Elimination Inspections** will occur to confirm that the facility remains closed and that declared equipment and buildings housing the equipment are eliminated. A last category of routine on-site verification, described herein as **Close-Out Inspections,** will take place to certify completion of destruction and of all agreed obligations regarding chemical weapons, thereby ending systematic monitoring of facilities.

Ad Hoc Inspections, as proposed, will take place on short notice at all declared "chemical weapon capable facilities" as they are selected from national registries of industry throughout the lifetime of the Convention.

Table 1-1 shows the verification activities for which cost estimates are presented in this paper. Additional on-site verification concepts and activities may be included in the final Convention.

Table I-1. On-Site Verification Activities

TYPE OF INSPECTION	FACILITY
* INITIAL INSPECTION	Storage, Destruction Chemical Weapon Production Schedules 1 and 2
* INITIAL VISIT	Schedule 2
INSTALLATION VISIT	Facilities selected for instrument monitoring
* PERMANENT PRESENCE	Destruction Storage (Interim)
* ROUTINE AND PERIODIC INSPECTIONS	Storage Destruction Chemical Weapon Production Schedules 1 and 2
CLOSURE INSPECTION	Chemical Weapon Production
SITE ELIMINATION INSPECTIONS	Chemical Weapon Production
ELIMINATION INSPECTIONS	Chemical Weapon Production Destruction
CLOSE-OUT INSPECTIONS	Storage, Destruction Chemical Weapon Production
AD HOC INSPECTIONS	All Declared and National Registry Facilities**

* Indicates titles found in the draft Convention.

** Proposed National Registers would list all relevant facilities of the chemical industry. See CD/869, CD/CW/WP.210, 6 September 1988, Federal Republic of Germany, Working Paper, Verification of Non-Production of Chemical Weapons, Ad Hoc Checks.

B. VERIFICATION PROVISIONS FOR STORAGE AND DESTRUCTION FACILITIES

The verification regime for storage and destruction facilities is given in Article IV and the detailed Annex. Systematic verification of facilities declared under Article IV is ensured by permitting access to chemical weapons at these facilities for on-site inspections and continuous monitoring with instruments. Or, if selected by the Technical Secretariat, some facilities will be monitored by the continuous presence of inspectors. Detailed inspection procedures will be elaborated in the facility agreements for the conduct of inspections and the use of monitoring instruments[10] at each facility and specify on-site monitoring instruments.

The draft CWC describes the verification process from confirming data declarations, designing inspection procedures and installing instruments as a sequence of activities after team arrival on site.[11] In this framework on-site verification at storage facilities is depicted by a series of on-site activities.

1. Storage Facilities

Storage facilities are the declared locations where chemical weapons are held until the weapons are removed to a destruction facility.[12] The verification aim is to account for all chemical weapons once declared by the State Party and thereafter to continuously monitor stockpile storage.

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10 CD/961 "Agreements on subsidiary arrangements" for Storage Facilities, page 68 and in the Model for Agreement, pages 173 - 177; Destruction Facilities, page 77.

11 The feasibility of installing the monitoring system, i.e., "initiating systematic monitoring" at the same time chemical weapon stockpiles are confirmed would depend on several factors. 1) Facility agreements would have to be concluded before or during the initial inspection. 2) The declaration submitted to the International Organization would need to incorporate sufficient detail on characteristics of the facility to allow the initial inspection team to bring with them pre-agreed types of equipment. The declaration would also need to be reviewed by technicians familiar with installation and operation of monitoring systems. 3) Installation of the monitoring system during the initial inspection also assumes that a prior on-site engineering survey (recognized in the Protocol on Inspections, page 137) of the facility characteristics is not essential although it is generally recognized that detailed information on the sites concerned will be necessary to plan and build the monitoring system. 4) The State Party would have to have completed site preparation at the facility for installation. This would include completion of arrangements for "necessary utilities", "basic construction materials" and logistical support for the transport of "installation tools, materials and equipment from the point of entry to the inspection site". See CD/961 page 137.

12 CD/961 Article IV Chemical Weapons, pages 16 - 17 and the Annex to Article IV, pages 65 - 80.

"Systematic monitoring"[13] of storage facilities implies the uninterrupted surveillance of chemical weapons. To ensure continuous surveillance, monitoring devices will be installed and the International Inspectorate will conduct routine on-site inspections. The draft CWC provides for verification by the permanent presence of inspectors when the Technical Secretariat determines that on-site monitoring with devices is not feasible for a particular facility.

a. Initial Inspections

The purpose of an initial inspection of a storage facility is to verify the accuracy of the information submitted by the State Party in the data declaration, develop the facility agreement and thereby plan future verification activities.

Inspectors will confirm that chemical weapons and facilities under control of the State Party are declared correctly by identifying the quantity of chemicals in the inventory, the form of storage, and the types and numbers of stored munitions, devices and equipment. Inspectors will check characteristics of the chemical stockpiles such as weight and fill of the declared items. Several options to achieve this verification aim are under discussion; they range from sampling every munition to relying on non-destructive interrogation techniques such as ultrasonics.[14]

The initial inspection is also undertaken to familiarize the inspection team with the unique features of the facility. The inspection team may then recommend which monitoring devices will be installed for surveillance and containment. Other advance preparations may be necessary to plan instrument installation; inspectors may observe facility boundaries, buildings, and supporting infrastructure-like utility lines. Inspectors will evaluate how the State Party stores chemical weapon stockpiles, determine whether inventory markers can be placed according to recommendations by the State Party, and judge stockpile configuration for access in future inspections. All storage areas and bunkers may be inventoried and the declared items sealed and marked. One of the proposed procedures for inventory control methods involves counting and tagging individual munitions.

The facility-specific nature of these activities suggests that initial inspections may be both labor- and time-intensive. The IDA estimate includes one initial inspection for 15 days on site by a team of six persons. This is assumed to be a minimum requirement if an

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13 CD/961 Article IV and the Annex to Article IV, Section II, paragraph 4(b) page 69.

14 Non-intrusive analytical techniques for inspection and verification are presented in CD/CW/WP.269, 12 January 1990, submitted by the United Kingdom of Great Britain and Northern Ireland.

extensive inventory is made of all munitions and bulk agents stored at the site. Ten days' preparation and recovery time is assumed per inspection to review the declaration and storage procedures.

b. Permanent Presence (Interim)

The draft Convention provides for the continuous presence of inspectors when facility agreements have not been completed and in the period before the monitoring system is installed and activated. The Convention now requires that the facility agreement be completed within 6 months after the Convention enters into force, yet the Initial Inspection is to occur promptly after a State Party submits a declaration--required within 30 days after the Convention enters into force. Therefore inspectors may be required to stay at the facility until remote monitoring becomes active. This interim presence may be withdrawn when a continuous monitoring system is installed unless the Technical Secretariat determines that both inspector presence and instrument monitoring are required. Our estimate for 24-hour coverage of the facility includes four inspectors on site for a maximum 5-month period.[15]

c. Installation Visit

The installation of on-site instruments initiates systematic verification cited by the CWC. After the declared inventory is confirmed during an initial inspection, stockpile storage areas will be secured and monitored thereafter by instruments to detect any attempts to remove chemical weapons. This verification aim is supported by methods proposed to seal or create entry barriers to storage areas. Surveillance and other equipment may include tamper-indicating seals, tags, video systems, sensors, and data authentication means.[16]

We count installation activities as a separate on-site visit. Our estimates assume that a team of five inspectors or skilled technicians is required on site for 5 days to install and conduct initial tests and certify equipment operation. Ten additional days are allotted for teams to review the site layout and plan work schedules.

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15 CD/961 brackets the time frame for conclusion of the agreement at six months. As implied by the brackets, this time period has not been agreed on. See Annex to Article IV, Section II, paragraph 3(a), page 68 and 5(c), page 69.

16 *The Report of the Technical Group on Instrumentation* discusses surveillance and containment, page 20.

d. Routine Inspection

The International Inspectorate will conduct routine inspections at storage facilities to confirm that the inventory remains as secured. Since following the draft CWC, inspectors will be present when chemical weapons are removed (discussed below under transfer activities), inspection teams will confirm that the inventory has not changed otherwise. Chemical weapons may remain in secure storage areas until State Parties have operational destruction facilities. Inspection teams may carry out routine inspections for several years at the same storage site to check inventory status until all chemical weapons are taken to destruction sites.

As they are now proposed, routine inspections include but are not limited to the following verification measures. Inspectors will choose inspection areas from permitted access arrangements for the facility. Inspection teams will select sealed storage areas and then determine a percentage of the inventory to be verified in that storage area. Inspection teams will examine, remove, and apply seals to chemical munitions, storage areas or bulk containers. Inspectors also may request samples from bulk containers and then may analyze these samples at the facility or, if permitted, in off-site laboratories. If samples are transferred for off-site analysis, inspectors will follow procedures to ensure the chain of custody and confidentiality of the samples.[17] Inspectors also will make routine checks of the monitoring system.

The International Authority will select facilities for inspection using a selection process that will not allow the sites to predict exactly when the inspection will occur. The frequency of inspections will depend on the specific facility agreement.[18] The IDA estimates assume annual routine inspections at storage facilities by an inspection team of six.[19]

e. Permanent Presence

The International Authority also may establish a permanent on-site presence of inspectors when the combination of instrument monitoring and on-site inspection is not

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17 Procedures for handling samples will involve packing samples in airtight containers and labeling relevant information. See *Technical Evaluation of Selected Scientific Methods for the Verification of Chemical Disarmament*, The Ministry For Foreign Affairs of Finland, page 31. Also see CD/961, pages 132-133.

18 Annex to Article IV, Section II, Paragraph 5.(f)(ii), page 71.

19 CD/961 Annex to Article IV, Section II, paragraph 3, page 68: "Such agreements shall be based on a Model Agreement and shall specify for each storage facility the number, intensity, duration of inspections, detailed inspection procedures and the installation, operation and maintenance of the seals and monitoring devices by the Technical Secretariat."

found feasible for the facility. Inspectors will perform the tasks described above for routine inspections including verifying the stockpile integrity by randomly selecting sealed storage areas for inspection. A permanent presence beyond a maximum 5-month period (interim) is not considered in our estimates.

f. Closeout Inspection

The International Inspectorate will conduct a final on-site inspection of each storage facility when all chemical weapons have been taken to destruction sites. This one-time inspection will be documented in a final report to the Technical Secretariat. Inspectors will certify the complete removal of all chemical weapons, systematic monitoring will end, and inspection teams will remove equipment. Our estimate involves two inspectors on site for 2 days with an additional 8 days for planning instrumentation removal.[20] Table I-2 summarizes the inspection framework pertaining to on-site activities at storage facilities.

Table I-2. On-Site Verification Activities at Storage Facilities

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY (YEAR)
INITIAL INSPECTION • Verify Data Declared - confirm information on quantity, identity and form of storage (types, numbers of munitions, devices & equipment) • Obtain Planning Information - evaluate site, location of storage areas, & inventory - survey for seal placement • Work On Facility Agreement - specify number, intensity, duration, & detailed inspection procedures • Inventory Control - secure, seal or mark - initiate monitoring by instruments or presence	6	15	10	25	1
PERMANENT PRESENCE (INTERIM) • Monitor by observation until system installed and activated	4	150	-	150	1
INSTALLATION VISIT • Initiate Instrument Monitoring - install, certify & test instruments • Secure Inventory - seal or establish barriers	5	5	10	15	1
ROUTINE INSPECTION • Verify Inventory Status - select items, areas and percent to inspect - confirm seal integrity - sample and analysis • Check Monitoring System - correct functioning of instruments - seals secure	6	5	8	13	1
CLOSEOUT INSPECTION • Document removal - certify in final report • Terminate Monitoring	2	2	8	10	1

20 Additional technical support personnel also may be needed for the removal of equipment although this is not represented in the estimates of team size.

2. Transfer Activities: Storage to Destruction

Inspectors are to be present when chemical munitions and chemical weapons are removed from secure storage facilities for transport to destruction sites.[21] Transfer verification requirements may be thought of as notification on-site activities since State Parties will notify the Technical Secretariat of the intended purpose and timing of stockpile removal.[22]

Inspectors will watch the loading of chemical weapons into vehicle transports and then will validate the remaining storage inventory. In so doing, inspectors will examine, remove, and replace inventory seals on monitored items. Inspectors will seal transports to prevent tampering, diversion, or substitution of the inventory. Inspectors will then verify the accuracy of the monitored inventory when the cargo arrives at the destruction site.

Verifying the transfer of chemical weapons is indispensable to the Convention's mandated goal of maintaining a chain of custody for declared inventories. Resource estimates are difficult to calculate although several variables can be identified that will affect the requirements for these related inspection activities: the proximity of storage sites to destruction facilities, the size and type of the shipment, the mode of transport, and country-specific considerations such as safety standards and other national regulations. For example, in the United States storage and destruction facilities are, on average, within a mile of each other. By comparison, the Soviet Union has a large stockpile, and many transfer inspections may be required if destruction facilities are built but not collocated with stockpile storage. Because of these complexities, we have not attempted to estimate costs corresponding to Transfer Activities.

3. Destruction Facilities

Destruction facilities are declared facilities where chemical agents and munitions are destroyed by an irreversible process. As mandated by the CWC, destruction will occur at facilities designed, constructed, equipped and operated for destruction of chemical weapons. Or a State Party will be allowed to convert a production facility on a temporary basis to destroy chemical weapons.

The objective of on-site verification is to confirm that the quantity of chemical weapons identified in the declaration is accounted for throughout the process of destruction

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21 CD/961, Annex to Article IV, Section II, paragraph 6, page 71.

22 CD/961, Annex to Article IV, Section II, paragraph 6 (a), page 71.

and to prove that the weapons are indeed destroyed.[23] Systematic verification for the active destruction of chemical weapons involves "the continuous presence of inspectors and continuous monitoring with instruments."[24]

The International Organization will monitor the destruction of chemical weapons through reviews of annual implementation plans received from the State Parties, through the presence of inspectors during active destruction periods, and through surveillance equipment during inactive periods if chemical weapons are present on site.

Verification provisions in the Annex to Article IV describe the responsibilities of the State Party. Beyond general guidance on environmental safety and the requirement that the process can be adequately verified, each State Party determines the destruction method.[25] The destruction process chosen--such as direct incineration and detoxification before incineration--must result in end products that cannot be used as chemical agents, munitions, or devices.

The order of destruction for chemical weapons is a contentious topic in the multilateral negotiations[26] and therefore has yet to be elaborated for inclusion in Convention text. However, the order of destruction pursued is intended to create confidence in the Convention in the early stage by building on "the undiminished security for all States."[27] The draft CWC recognizes destruction stages of nine annual periods although the negotiators have not yet agreed to the amount to be destroyed by each State Party and the manner in which this percentage will be measured in each annual period.[28] We have assumed in our estimates that the destruction phase ends no later than 10 years after the Convention enters into force.

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23 CD/961 Annex to Article IV, Section V, 1, page 75.

24 CD/961 Article IV, paragraph 6, page 17.

25 CD/961 Annex to Article IV, Section III, paragraph 2, page 73. "The following processes may not be used, dumping in any body of water, land burial, or open pit burning."

26 The consultations held on the order of destruction by the Chairman of Group B in 1988 are reported in Appendix II, *Principles and Order of Destruction of Chemical Weapons*, pages 153 - 154. Also CD/822 of 29 March 1988 includes a proposal for a phased destruction approach that includes advance destruction by the largest chemical weapons states. The order of destruction is also addressed in the bilateral discussions between the United States and the Soviet Union.

27 CD/961, Annex to Article IV, Section IV, paragraph 1, page 73.

28 CD/961, Annex to Article IV, Section IV, paragraph 2, page 74.

a. Initial Inspection

The verification purpose of an initial inspection is to confirm the State Party's declaration on the location, quantity, and inventory of chemical weapons and information from the "General Plan" for destruction including method and schedules.[29] In addition, it may confirm the information in the "Detailed Plan"[30] when the State Party has submitted a specific destruction plan in advance of the destruction period for individual facilities.

Verification activities during initial inspections will vary with respect to the status of individual facilities and when the inspection occurs. Although each State Party will submit a General Plan for destruction when the declaration is submitted, many State Parties will not have existing facilities ready to begin actual destruction. Consequently, initial inspections may be conducted to meet on-site verification objectives described in the following paragraphs.

An initial inspection may be carried out to confirm details of the combined destruction and verification plan or to judge how monitoring equipment might be adapted to the specific destruction method used by the State Party.

An initial inspection at a State Party's facility for which a Detailed Plan has been submitted for specific destruction will involve inspection tasks to confirm the additional information on the aggregate quantity of chemical weapons to be destroyed at the individual facility. Also, if chemical weapons are present at a destruction facility, then the inspection team will confirm the inventory of declared chemical weapons and begin control procedures to monitor and secure stockpiles.

An initial inspection also may be conducted as an engineering survey to evaluate the State Party's plan to destroy specific types and quantities of chemical weapons in planned periods. Inspectors may need to assess the destruction method with respect to capacity, schedules and storage for different types of chemical weapons or agents.

An initial inspection will require at least six inspectors on site for 10 days when the inspection is conducted primarily for planning purposes. In addition, 15 days are added for preparation of engineering reviews before team arrival.

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29 The format of the General Plan is given in the Annex, page 75.

30 The format for the Detailed Plans are given in the Annex to Article IV, on page 75-76.

b. Permanent Presence (Interim)

An interim presence may be required if chemical weapons are stored at holding areas at declared destruction facilities. The draft Convention calls for the presence of inspectors on site to observe chemical weapon stockpile storage until systematic monitoring is initiated by the installation and activation of monitoring equipment.[31]

Since the Convention now allows 6 months for completion of the facility agreement, an interim permanent presence would be required only if there were "chemical weapons storage facilities at chemical weapon destruction facilities" and when the Initial Inspection was to occur promptly after submission of a declaration.[32]

To develop annual cost estimates, four destruction facilities are assumed to be operational in the first year after the Convention enters into force.[33] The estimates include an interim presence of four permanent inspectors for a maximum 5-month period to implement the verification provisions outlined for storage facilities.[34]

c. Installation Visit

Continuous monitoring of the destruction process is considered critical to the systematic verification goals of the CWC. Extensive effort has gone into analyzing equipment to support this aim although concrete examples of a destruction facility and process are found only in the US--the only nation with an operational destruction facility.

This study does not assess potential technology applications. However, in order to extrapolate cost elements related to CWC verification, we count on-site visits to install monitoring devices. Devices that weigh or count munitions may be utilized, or equipment may be installed to allow sample collection from key points in the destruction process.

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31 See CD/961.

32 See CD/961, *Chemical Weapons Storage Facilities at Chemical Weapons Destruction Facilities*, Annex to Article V, page 79 and paragraph 5, page 69.

33 A schedule for operating destruction facilities cannot be forecast from present information on only the planned U.S. facilities. However, by illustration, if the Convention enters into force three years hence, the United States may be operating two facilities and the Soviet Union may be involved in destruction at one or more facilities. A few nations may be ready to destroy abandoned munitions discovered on their territory. Converted production facilities also may become operational the first year.

34 CD/961, page 80: "As soon and as long as chemical weapons are stored at chemical weapons storage facilities at chemical weapon destruction facilities, these storage facilities shall be subject to international systematic monitoring, as referred to in relevant provisions of paragraph 5 of section II of the present Annex, in conformity with the relevant agreements on subsidiary arrangements or, if no such agreement has been concluded, with the agreed combined plan for destruction and verification."

Additionally, surveillance and containment equipment may be required to monitor remaining stockpiles during periods of inactivity.[35]

A team comprising appropriate technical specialities and support personnel is assumed necessary to carry out the installation, testing, and certification of monitoring equipment. Installation of equipment is assumed to require five people on site for 5 days with an additional 15 days added for review of instrumentation procedures for the facility.

d. Permanent Presence: Active Destruction

Article IV calls for the continuous presence of inspectors and continuous monitoring with on-site instruments to verify the destruction of chemical weapons and agents. The Technical Secretariat will determine requirements for the presence of an on-site inspector during planned destruction activities when the State Party plans are received and reviewed.[36]

The verification objective is to oversee all facility activities related to destruction and process monitoring equipment. As outlined by the Annex, inspectors may monitor by either observation or devices.[37] Inspection teams will monitor the movement of chemical weapons, ensure that diversion does not occur, and maintain the accuracy and calibration of the monitoring equipment.

Inspectors will monitor the material balance as materials pass through the destruction process and are destroyed. Inspectors will then certify the designated quantity destroyed in each destruction period. Inspectors may chose items for inspection in accordance with the facility agreement and request samples for analysis. Other inspection tasks will include frequent retrieval of data from on-site instrumentation and review of facility operation records.

In developing our estimates for the permanent presence of inspectors, we assumed that a given number of destruction facilities would be active in each of the first 10 years after the Convention enters into force. We also assumed that the destruction period for each operational facility would last 1 year. More specifically, four facilities are assumed to be operating in the first and second year, 12 facilities in the third year, 15 facilities in the

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35 CD/961: pages 79-80, "They shall employ, as appropriate, agreed seals, markers or other inventory control procedures to facilitate an accurate inventory," and, "The International Inspectors will make any appropriate adjustments in the monitoring system in accordance with the relevant agreement on subsidiary arrangements whenever inventory changes occur."

36 The review process is discussed in CD/961, pages 76-77.

37 CD/961, Annex to Article IV, Section V, paragraph 7(b), page 78.

fourth year, 13 in the fifth year, and 10 in years 6 through 10. Manpower estimates for each facility include four inspectors on site for 24-hour coverage. (See Chapter II.)

e. Closeout Inspection

The International Inspectorate will conduct closeout on-site inspections at destruction facilities to certify the destruction and removal of all chemical weapon stockpiles. Certification of the completed destruction process then will allow the removal of equipment and the termination of monitoring at of the facility.

Our base case estimates include 2 on-site days for inspectors to make a final walk-through of the facility. Table I-3 summarizes the inspection framework at destruction facilities.

Table I-3. On-Site Verification Activities at Destruction Facilities

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY (YEAR)
INITIAL INSPECTION • Verify Data Declared - confirm details of General or Detailed Plan - confirm quantity & identity if chemical weapons are present • Obtain Planning Information - engineering review of characteristics, mode of operation, layout & scheme - evaluate and review specific plans for combined destruction and verification • Work On Facility Agreement - detail inspection procedures for inspections, removal & transport • Inventory Control - secure, seal or mark - initiate monitoring by instruments or presence	6	10	15	25	1
PERMANENT PRESENCE (INTERIM) • Monitor stockpiles until secured	4	150	–	150	1
INSTALLATION VISIT • Initiate Instrument Monitoring - *install, certify, test instruments* • Secure Inventory - reestablish seals	5	5	15	20	1
PERMANENT PRESENCE (ACTIVE DESTRUCTION PERIODS) • Verify Destruction - certify percentage of stocks destroyed - monitor material balance, movement and removal - retrieve instrument data - sample & analysis	4	365	0	365	1
CLOSEOUT INSPECTION • Document Completion - certify stocks destroyed for final report • Terminate Monitoring	2	2	8	10	1

C. VERIFICATION PROVISIONS FOR CHEMICAL WEAPONS PRODUCTION FACILITIES

Chemical weapons production facilities are declared locations where chemical weapons have been produced.[38] Under the Convention, all activity except that related to closure should end immediately and facilities should close within 3 months of the Convention s entry into force.[39]

By definition, "chemical weapons production facility" covers buildings, housing, and equipment designed, constructed, or used for producing chemical weapons. The definition also applies to facilities used for filling chemical munitions.[40]

The verification aim is to ensure that the facility is inoperable until destruction of facilities and equipment is completed no later than 10 years after the Convention enters into force.

Verification provisions for such facilities are found in Article III for declarations, and in Article V and its supporting Annex for facilities.[41] Systematic verification applied to chemical weapons production facilities implies routine on-site inspections on a periodic basis and continuous monitoring with instruments. Continuous monitoring will remain in effect until the facility and related equipment are destroyed.[42] Verification arrangements will be developed in facility agreements for each facility derived from a generally applicable model for agreement.[43] Guidelines in a final Convention will be elaborated for use in determining the frequency of inspections.

1. Initial Inspection

The verification aim of an initial inspection is to confirm that all activity except measures required to close the facility has ceased .[44] Inspection teams will establish the

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38 The definition of a chemical weapon under discussion at the Conference on Disarmament is found in Article II, pages 11 - 12. Agreement has not been reached on this definition.

39 CD/961, Article V, paragraphs 2 and 6(a) page 18.

40 Definitions for the term chemical weapons production facilities are found in CD/961 on pages 13 and 84 - 85. Agreement has not been reached on this definition.

41 CD/961, Article III, page 14; Article V, page 18; Annex to Article V, page 81.

42 The order of destruction for chemical weapons facilities is not developed in draft CWC text.

43 Currently, CD/961 does not include a model for agreement for chemical weapons production facilities as it does for Storage, Schedule 1 and Schedule 2 facilities.

44 CD/961, Annex to Article V, Section V, page 87.

accuracy of information submitted in the declaration, plan future verification measures for the facility, specify monitoring devices, and develop the facility agreements.[45]

Each State Party will declare all production facilities under its control or jurisdiction. Also as part of the declaration, the State Party will specify actions to be taken for closure of the facility and will outline a General Plan for destruction. If the State Party elects to temporarily convert a production facility to destruction purposes, the State Party also will submit a general conversion plan.[46]

To confirm the accuracy of the declarations on production and filling facilities, international inspectors will verify information on the location, ownership, operation and control of the facility. Inspectors will evaluate products of the facility, the capacity, and detailed data provided in the facility description.[47] Inspection teams also will consider chemicals produced or will identify the chemical fill of the declared munitions. The International Inspectorate will establish the accuracy of reported capacity by assessing the quantity of end-products produced by the facility in a given period of operation.[48] Additional confirmation will be obtained by reviewing the facility layout and process flow diagrams and by conducting a detailed inventory of on-site equipment and buildings.[49]

The draft CWC also calls for the initiation of inventory control procedures during this inspection by installing devices to detect attempts to remove declared items. The current time period allowed for conclusion of agreements specifying which instruments will be used is bracketed in draft CWC text at 6 months. The initial on-site verification is to be conducted promptly -- "not later than [60] days after a declaration is submitted."[50]

We have assumed that this inspection involves six inspectors on site for 10 days to confirm the declaration. Ten days of preparation and recovery time are added to account for time to review and familiarize the inspectorate with the facility.

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45 CD/961, Addendum to Appendix I, Protocol on Inspection Procedures, Part II, Section I, paragraphs 1 and 2, page 136.

46 CD/961, Article V, paragraph 4(e) page 18. Activities related to temporary conversion of facilities is to be developed for inclusion in the Annex to Article V, page 85.

47 CD/961, Annex to Article V, page 81, covers the declaration for chemical weapons production facilities.

48 CD/961, Annex to Article V, Section I, paragraph 5 (a)(b), page 81.

49 CD/961, Annex to Article V, Section I, paragraph 6, (a) (b) (c), page 81.

50 CD/961, Annex to Article V, Section V, paragraph 1(a)(ii), page 88.

2. Closure Inspection (Initial)

The verification aim of the closure inspection is to confirm that the facility is inoperable. Accordingly, International Inspectors will survey the facility to determine that the State Party has completed all specified actions for closure.[51] Inspectors will certify evidence of closure that may include abandoned buildings, disconnected or disassembled equipment related to the production process, and interrupted rail and utility lines (as safety permits). Thereafter, periodic closure inspections will be carried out until the facility is destroyed to monitor that production does not restart.

The initial closure inspection included in our estimates provides for six inspectors to be on site one time for 2 days.

3. Installation Visit

The verification objective of instrument monitoring is to ensure that the facility remains inactive with respect to production. The draft CWC plans continuous monitoring with on-site instruments to establish that production cannot be resumed and that items declared in the inventory are not removed from the facility. Equipment considered for monitoring chemical weapons production facilities primarily includes surveillance and containment equipment,[52] although equipment selection will depend on the methods used by the State Party to deactivate the facility. As now understood, surveillance and containment equipment include tamper-indicating seals and video systems, supplemented by sensors and data authentication devices.[53]

Our estimates include an installation visit on site by an inspection team of five inspectors for 2 days with 15 days allowed for preparation and recovery.

4. Routine Inspections

Routine on-site inspections of former chemical weapons production facilities occur to meet two verification aims of the CWC: 1) to confirm that the facility is inactive with regard to production, and 2) to observe elimination of standard and specialized equipment and buildings.

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51 CD/961, Article V, paragraph 4(c), page 18, and Annex to Article V, Section IIB, paragraphs 1 and 2, page 83.

52 See Report of the Technical Group on Instrumentation, page 24.

53 CD/961, Annex to Article V, Section 5, paragraph 4, pages 89 - 90.

The verification objective at production facilities at any given time depends on the State Party's destruction plan and schedule. For example, in the third year, a State Party may have an inactive facility ("closed" in CWC terminology) and a facility where elimination of equipment or buildings is in progress. We describe these verification objectives by two different types of on-site verification: Closure Inspection and Elimination Inspection.

Closure Inspections. The International Inspectorate will conduct routine closure inspections on a periodic basis (after the initial closure inspection) to observe evidence that the facility cannot or has not produced chemical weapons. Evidence of a closed facility will be found by observing, for example, disassembled components of process or safety equipment. These inspections will continue until the equipment and facility are destroyed in a manner that cannot lead to reassembly of production capacity.

Our estimate includes an annual inspection to verify closure by a team of four inspectors on site for 2 days.

Site Elimination and Equipment Elimination Inspections. This section describes CWC objectives for verifying destruction of chemical weapons production facilities. In the framework, this verification aim is tied to biannual elimination inspections to confirm that each declared item in the inventory, and the facility, is destroyed[54] according to an agreed plan.

Consultations between the International Organization and the State Party will result in an agreed plan for verifying destruction. As stated in the draft CWC, verification "should be conducted through the presence of on-site Inspectors to witness destruction." [55] The State Party's destruction plan and proposed verification measures will be reviewed by the Technical Secretariat, which will then prepare a combined plan for verifying destruction at each facility. Agreement on this combined plan is to be completed 60 days before destruction begins, and this plan will be incorporated by the State Party in its destruction at the facility.[56] Thus, on-site elimination inspections may be conducted as part of the process leading to approval of the State Party destruction plan or conducted to monitor destruction of chemical weapons-specific equipment and facilities.

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54 CD/961, Annex to Article V, Section V, paragraph 5, page 91.

55 CD/961, Annex to Article V, page 92.

56 CD/961, Annex to Article V, Section IV, pages 86 - 87, gives the format of the General Plan and the Detailed Plans for destruction.

While the draft CWC describes destruction verification as implementing an agreed plan "through the presence of on-site Inspectors to witness the destruction,"[57] the Convention lacks important details pertaining to the verification process. The draft CWC is not clear on what constitutes verifying destruction in terms of observing the transformation or disposal of equipment and buildings. So although the timing of the presence of inspectors will be determined by the agreed plan for each facility, it remains to be elaborated in the draft text how much of the actual destruction process will be witnessed by on-site inspectors. The destruction process in the United States at Rocky Mountain Arsenal, for example, has involved a long process to demolish and then incinerate equipment.[58]

Inspection teams will conduct elimination inspections to observe the physical destruction of "specialized equipment" (which will include components of the main production train such as reactors, chemical weapon filling machines, or special equipment for waste control) and destruction of "standard equipment" (such as safety surveillance equipment, buildings in a production configuration, and facilities and equipment designed or used exclusively for producing non-chemical parts of chemical munitions).[59] Our estimates include biannual elimination inspections by a team of four inspectors on site for 2 days.

5. Permanent Presence

The draft CWC addresses requirements for the permanent presence of inspectors when continuous monitoring instruments are not found adequate or feasible for a facility. There are two additional cases where the presence of inspectors is stipulated for specific periods: 1) the period before the facility agreement is concluded and therefore before the monitoring system is installed and activated,[60] and 2) when the Technical Secretariat and the State Party are unable to reach agreement on verification of a destruction plan.[61] Consistent with draft CWC language, other situations also may be considered appropriate for the presence of inspectors for indefinite periods of time. For example, in the case of

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57 CD/961, Annex to Article V, Section 5, paragraph 5, pages 91 - 92.

58 For example, estimates for the amount of rubble produced in the destruction process at Rocky Mountain Arsenal are above the 100,000 ton range.

59 CD/961, Annex to Article V, C, pages 84 - 85.

60 CD/961, Annex to Article V, Section V, paragraph 4, page 89.

61 CD/961, Annex V to Article V, page 92: "If agreement is not reached with the Executive Council on aspects of verification, or if the approved verification plan cannot be put into action, verification of destruction will proceed by the continuous on-site monitoring and presence of Inspectors."

equipment malfunction, or if the monitoring system at the facility indicates an irregularity, an interim inspector presence may be established until the monitoring system is restored. Our base case estimates do not include an interim presence of inspectors for the above conditional examples.

6. Closeout Inspection

A final on-site closeout inspection will be conducted to certify the complete destruction of all buildings, structures, and equipment in the declared inventory. A closeout inspection is estimated to involve four inspectors for 2 days. Table I-4 summarizes the inspection framework for production facilities.

Table I-4. On-Site Verification Activities at Chemical Weapons Production Facilities

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY (YEAR)
INITIAL INSPECTION	6	10	10	20	1
• Verify Inactivity Except Related to Closure • Verify Data Declared - inventory of items: equipment and buildings - review plans for closure and general plan for destruction • Obtain Planning Information - evaluate site layout & process & location of inventory • Negotiate Facility Agreement - detail inspection procedures - coordinate measures for instrument monitoring					
CLOSURE INSPECTION (INITIAL) (After 3 months entry into force)	6	2	8	10	1
• Confirm Facility Inoperable - verify closure completed - observe evidence of disconnected or disabled equipment • Inventory Control - secure, seal, mark items					
INSTALLATION VISIT	5	5	15	20	1
• Initiate Instrument Monitoring - install, certify & test instruments					
ROUTINE INSPECTIONS	4	2	8	10	1
1) CLOSURE INSPECTIONS (REOCCURRING) • Confirm Facility Inactive With Regard to Production - observe evidence of non-production - establish facility not operable or reassembled					
2) ELIMINATION INSPECTIONS	4	2	8	10	2
• Witness Destruction - monitor dismantlement & destruction of buildings and equipment - confirm destruction follows agreed plan					
CLOSEOUT INSPECTIONS	2	1	5	6	1
• Document Completed Destruction - certify in final report • Terminate Monitoring					

D. VERIFICATION PROVISIONS FOR PERMITTED ACTIVITIES

Article VI, *Activities Not Prohibited by the Convention*, acknowledges the right of State Parties to develop, produce, and use toxic chemicals and their precursors for specific applications. The verification regimes for permitted activities correspond to three lists of chemicals referred to as Schedules 1, 2 (A & B) and 3. Chemicals are evaluated by reviewing criteria that assign chemicals to the Schedules based on their potential contribution to chemical warfare agent production and by considering the quantities produced in modern industry. These guidelines then form the basis for determining the risk to the Convention's overall goal as a total prohibition on the production of chemical weapons.

Schedule 1 chemicals primarily include known and tested chemical warfare agents or chemicals closely related to the known agent; they have limited commercial application. Schedule 1 chemicals pose a "high risk" to Convention objectives because of their "high potential" for use in the production of chemical weapons.

Schedule 2A chemicals are precursors to chemicals found in Schedule 1. While these chemicals are produced substantially in commercial industry, they pose a "significant risk" because of their importance in the production of Schedule 1 chemicals.[62]

Schedule 3 chemicals include precursor chemicals like chlorinating agents. Although first-generation chemical warfare agents such as phosgene are included in this Schedule, they are considered "outmoded" by modern definitions and are produced in such vast quantities that an extensive control regime is not feasible. Schedule 3 chemicals are therefore monitored by data declarations because they pose "a risk" due to their "importance" in the production of other chemicals listed in Schedules 1 and 2.

Separate Annexes to Article VI outline verification provisions for facilities that produce, process, or consume chemicals listed in the Schedules. Thus, the verification effort follows graded levels of monitoring for each type of facility. The Technical Secretariat will monitor these chemical facilities through data reports from the State Party, on-site instruments, and routine on-site inspections.

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62 Guidelines for chemicals to be included in Schedule 2B are under consideration. This category has been added to capture highly toxic substances which are not precursor chemicals but are "deemed to pose a risk to the objectives of the Convention." Amiton is now listed in Schedule 2, and views have been expressed about including saxitoxin, ricin, and PFIB in Schedule 2B. CD/961, pages 44 and 47.

The Technical Secretariat uses general "models for agreement"[63] to design the specific verification arrangements for individual facilities. The agreements will specify the number, intensity, and duration of inspections and will detail procedures for instrument operation.[64] The Technical Secretariat also will determine the frequency of inspections at individual facilities by weighing the risks outlined by guidelines for the Schedule chemicals in use and by considering the activities and characteristics of the facility.[65]

Table I-5. On-Site Verification Activities at Schedule 1 Facilities

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY (YEAR)
SCHEDULE 1					
INITIAL INSPECTION • Verify Data Declared - inventory; equipment, feedstocks, storage & production capacity • Obtain Planning Information - technical evaluation of process - review previous year production, confirm capacity not in excess of limits, evaluate production & processing flows • Work On Facility Agreement - detail inspection procedures, frequency and mode - plan placement of monitors	6	8	10	18	1
INSTALLATION VISIT • Initiate Instrument Monitoring - install, certify, & test instruments	5	5	15	20	1
ROUTINE INSPECTION • Inspect Process - establish within production limits - establish quantities reported correctly and compatible with end-needs - re-evaluate process parameters - examine records, equipment - sample & analysis - investigate irregularities	2	2	8	10	1

1. Schedule 1 Facilities

The CWC will limit the production of Schedule 1 chemicals to no more than a metric ton for each State Party.[66] Schedule 1 production will be allowed at one small-scale

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63 CD/961, Appendix II includes two models for agreement that require additional discussion in the negotiations. *Model for an Agreement Relating to Single Small-Scale Facilities* is on pages 167 - 171. *Model for an Agreement Relating to Facilities Producing, Processing or Consuming Chemicals listed in Schedule 2* is on pages 161 - 166. The draft CWC does not apply time frames for concluding facility agreements consistently throughout the draft text. For example, time frames under discussion for single small-scale facilities range from 3 to 12 months (page 99).

64 CD/961, Annex 2 to Article VI, paragraphs 11 and 12, page 107.

65 CD/961, Annex 1 to Article VI, Section II, paragraph 3, page 98.

66 CD/961, Annex 1 to Article VI, page 96.

facility and in limited quantities outside this facility.[67] The activities shown in Table I-5 will be carried out to verify compliance with these stipulations.

a. Single Small-Scale Facilities

The verification aim for single small-scale facilities is to ensure that Schedule 1 chemicals are declared correctly, produced in quantities no greater than 1 metric ton, and used only for purposes allowed by the Convention. The International Inspectorate will verify production limitations on plant capacity at declared facilities and will monitor total production.

The proposed control regime for small-scale facilities is stringent: chemical types and quantities must be justified for permitted research, and medical, pharmaceutical, or protective purposes. International monitoring of these facilities is by on-site inspection and with on-site instruments.[68]

Initial Inspection. The verification aim of the initial inspection[69] is to verify information in the declaration and to obtain additional planning information for future inspections and instrument monitoring. Representative inspector tasks are given to summarize the content of the declaration to be confirmed and the detailed facility agreements.

Inspection teams will evaluate process parameters to use as a comparison for subsequent routine inspections. Inspectors will evaluate the production capacity of the facility by confirming that the facility is not designed for continuous operation and that the reactor size is within CWC limits.[70]

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67 CD/961, Annex 1 to Article VI, page 96: "2. (a) Production of Schedule 1 chemicals in aggregate quantities not exceeding 10 kg per year may be carried out for protective purposes at one facility outside a single small-scale facility. (b) Production of Schedule 1 chemicals in aggregate quantities of more than 100 g per year may be carried out for research, medical or pharmaceutical purposes outside a small-scale facility in aggregate quantities not exceeding 10 kg per year per facility. 3. Synthesis of Schedule 1 chemicals for research, medical, or pharmaceutical purposes, may be carried out at laboratories [approved by the State Party] in aggregate quantities less than 100 g per facility."

68 CD/961, Annex 1 to Article VI, pages 96 and 98: "The single small-scale facility shall be subject to systematic international on-site verification, through on-site inspection and monitoring with instruments."

69 The term "initial visit" is used in CD/961, Annex 1 to Article VI, Section II, paragraph 4, page 98, but the term "initial inspection" is used in the Protocol on Inspections that is a later addition to the draft text. As the depiction of required activities is similar, the term initial inspection is used in this paper at Schedule 1 facilities to refer to the first on-site presence at facilities.

70 The limitation on reactor size is still under discussion at the Conference. The draft text now brackets reactor size at 10 and 100 liters.

As inspections at each small-scale facility are conducted to prove that production does not exceed permitted amounts, inspectors will review data on the production process and examine equipment and technology. To confirm that Schedule 1 chemicals are not diverted and that chemical use is reported accurately, inspectors will examine facility records and develop a material balance among chemical quantities and consumption flows. They may inspect storage capacity for chemicals and feedstocks and examine waste treatment methods at the facility.

Also during the initial inspection, teams will design specific arrangements for the individual facility by following the model agreement.[71] To develop this agreement, inspectors will observe technical characteristics of the facility and determine which areas of the facility will be inspected, where samples will be taken, what analytical instruments will be used during inspections, and whether instrument monitoring equipment will be installed at the facility.

Installation Inspection. Appropriate on-site monitoring instrumentation will depend on design capacity of the production unit as well as the State Party's planned activities for the facility. Suggested instrumentation methods include equipment for facility surveillance and process monitoring.

Surveillance and containment measures to ensure that production batches are not diverted have been proposed, although the specific method would depend on facility design. For example, if the facility uses 10-liter reactors, the Technical Group on Instrumentation noted that surveillance and containment methods may be of limited use and that it may be more appropriate to have inspectors present during agent synthesis.[72]

Suggested process control instruments may include monitoring devices to measure or indicate excess production. In some cases, process monitoring may occur by measuring variables not directly connected with the process such as water supply and electricity. The "monitoring system" in the draft CWC lists sensors and other equipment, a data transmission system and ancillary equipment. The installation of any type of process monitoring equipment would require inspection teams to calibrate the equipment for precision and accuracy.

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71 *Model for an Agreement Relating to Single Small Scale Facilities*, pages 167 - 171.

72 *Report of the Technical Group on Instrumentation*, page 26.

Our estimate for the installation visit includes five inspectors on site for 5 days with 15 days of preparation and recovery time included for technical oversight of equipment requirements.

Routine Inspection. The International Inspectorate will conduct routine inspections at small-scale facilities. The verification aim is to confirm that the facility is not used to produce any chemicals listed in Schedule 1 except for chemicals declared in initial or annual declarations. Inspection teams will establish that quantities of Schedule 1 chemicals produced, processed, and consumed are correctly reported and compatible with declared production purposes.

Inspectors will examine equipment, compare the process parameters ascertained in earlier inspections, and evaluate any technological changes to the production process. Inspectors will review accounting and operating records and inventory chemicals and equipment. Inspection teams will check on-site instrumentation and perform routine maintenance as needed. Inspectors may be required to validate measuring equipment by examining and calibrating the instruments. Inspectors may request samples from the production line or from bulk storage and perform on-site or off-site analysis as provided for in the sampling plan in the facility agreement.

b. Other Schedule 1 Facilities

The verification aim for facilities producing Schedule 1 chemicals in aggregate amounts of less than 10 kg per year and greater than 100 g is to confirm that the facility only produces permitted quantities of the declared chemical for reported needs and that the chemicals are not diverted to other purposes.[73] The verification measures will follow the same description given for the single small-scale facilities.

2. Schedule 2 Chemical Production Facilities

Article VI and Annex 2 to Article VI outline the verification regime for Schedule 2 chemical facilities. Under the CWC, these facilities[74] will be monitored by annual data

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73 CD/961, Annex to Article VI, pages 100 - 102 cover the declaration and the verification provisions.

74 CD/961, Article VI, Paragraph 5, page 20: "Each State Party undertakes to subject chemicals listed in Schedule 2, parts A and B and facilities declared under Annex 2 to this Article to monitoring by data reporting and routine systematic international on-site verification, through on-site inspection and use of on-site instruments as long as production and processing are not impaired." Also see Annex 1 to Article VI, Section II, paragraph 2, page 98.

declarations on production, processing, and consumption of Schedule 2 chemicals.[75] These facilities also will be subject to routine on-site inspections and the use of on-site instruments as long as production is not impaired.[76]

Chemicals listed in Schedule 2 are produced and used in many facilities worldwide for a variety of legitimate commercial applications. The verification aim for commercial facilities is to ensure that these facilities are not used to produce Schedule 1 chemicals, that quantities of Schedule 2 chemicals are consistent with the end products produced, and that Schedule 2 chemicals are not diverted for prohibited purposes.[77] These activities are summarized in Table I-6.

a. Initial Visit

The verification aim of the initial visit at commercial Schedule 2 chemical facilities[78] is to negotiate the facility agreement with facility representatives before an inspection takes place.[79] The details of the model agreement are summarized by describing the purpose of the visit as outlined in the draft CWC and as followed in National Trial Inspections.

Inspectors will observe the plant layout and the operational and process characteristics of the facility to judge the risk that the facility could be used for prohibited purposes and to determine the frequency of inspections.[80] For example, inspectors may look at the plant layout and the equipment design, feedstocks, and precursor chemicals used or stored on site. Inspection teams will observe safety and containment features to determine whether the plant could be readily converted to Schedule 1 chemical production. In some cases, inspectors may evaluate the chemical process used to determine how

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75 The United States proposed thresholds for Schedule 2 verification that would subject facilities of more than 10 tons a year to monitoring by annual data declarations and on-site inspection at least once a year. Facilities from 1 ton to 10 tons a year would be monitored by annual data declarations, and Schedule 2 facilities of up to 1000 kg a year would not be monitored. CD/802, CD/CW/WP.186, 5 February 1988. The draft CWC acknowledges thresholds for Schedule 2 facilities in Annex 2 to Article VI, page 103 although the threshold amounts are not defined.

76 CD/961, Article VI, paragraph 6, page 20.

77 CD/961, Annex 2 to Article VI, paragraph 4, page 105.

78 Agreement on thresholds will determine the number of facilities subject to an on-site inspection regime. See CD/802, CD/CW/WP.186, 5 February 1988, U.S.A.: "Thresholds for monitoring chemical activities not prohibited by a convention."

79 Several delegations, including the United States, point out the importance of the initial visit. Some delegations report that the initial visit may take twice as long as the initial inspection.

80 CD/961, Appendix II, *Possible Factors Identified to Determine the Number, Intensity, Duration, Timing, and Mode of Inspections of Facilities Handling Schedule 2 Chemicals*, pages 157 - 159.

process parameters, such as the thermal and pressure conditions of the overall process, could be used for continuous monitoring.

Table I-6. On-Site Verification Activities at Schedule 2 Chemical Facilities

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY (YEAR)
INITIAL VISIT					
• **Work On Facility Agreement**	6	4	10	14	2
- hold technical consultation					
- detail measures for inspections; number, timing and mode					
- determine access, review site plans and process diagrams					
• **Obtain Planning Information**					
- observe design characteristics and relevant equipment, chemicals and process employed					
- judge facility risk factor					
- define points for sample collection					
- evaluate points for monitoring equipment and measuring devices					
- identify facility documentation					
INITIAL INSPECTION	6	2	8	10	1
• **Verify Declaration**					
- confirm site characteristics					
- review declaration for production data					
• **Confirm Non-Use for Schedule 1 Chemicals**					
• **Confirm Quantities Consistent with Needs**					
• **Confirm Non-Diversion of Schedule Chemicals**					
- consider process parameters, calculate production capacity, end products and equipment					
- review plant operations, feedstocks and end-products					
- evaluate use rates for normal activities					
- construct working material balance					
• audit chemical inventory and operating records for raw material usage					
- observe process and handling of Schedule chemicals					
- sample and analysis					
INSTALLATION VISIT	5	5	15	20	1
• **Initiate Facility Monitoring Measures**					
- install diversion indicators					
- test and certify instruments					
ROUTINE INSPECTIONS	6	2	8	10	1
• **Confirm Non-Use for Schedule 1 Chemicals**					
• **Confirm Quantities Consistent With Needs**					
• **Confirm Non-Diversion of Schedule Chemicals**					
- follow activities for initial inspection					

Also, in order to design verification measures for the facility, inspectors may examine maps and facility site plans to locate relevant buildings, structures, plants and critical equipment within the site and to identify borders and pipelines entering the facility. The inspection team will consider all other areas of the site that inspectors may require access to during routine inspections. Inspection areas may include storage areas for feedstocks, effluent and waste treatment areas, control or analytical laboratories, and interconnecting pipework between installations. Inspection teams will consider equipment on site to confirm the reported activities for the facility and to identify sampling points on key equipment for routine inspections. Additionally, inspection teams will identify the facility documents that inspectors will examine in future inspections.

b. Initial Inspection

The verification aim of an initial inspection is to confirm the detailed information in the declaration for each facility.[81] Inspection team tasks to summarize the declaration are described in the following paragraphs.

Declared activities involving the Schedule chemicals at the facility will be investigated to confirm that Schedule 2 chemicals are not diverted to prohibited purposes.[82] Inspection teams will thereby confirm the chemicals in use by name, structural formula, and final products produced at the facility. Inspection teams will compare declared products with the type of processes used, such as production by a particular batch process in a multipurpose production unit.

Inspectors will examine production records to construct a working material balance by looking at starting materials to account for the use of chemical feedstocks. Inspectors may track quantities of chemicals moved through the process unit by examining inventory records for raw materials and final products.

Inspectors also will assess past-year production and will estimate maximum annual production capacity.[83] Inspectors will conduct a records audit by analyzing raw material usage and daily operating logs to determine production quantities. Production estimates will compare records on equipment usage combined with records on feedstock receipts, product shipments, inventories, and documentation on clean-up and waste disposal operations.[84]

Inspection teams will observe the processing and handling of Schedule 2 chemicals to confirm whether any Schedule 2 chemical is processed or converted to another chemical. For example, a facility may consume a Schedule 2 chemical as a feedstock and produce another Schedule 2 chemical as a final product.

Inspection teams will identify the inspection areas at the complex: buildings, production units, reactors, and process equipment included in the declared production

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81 CD/961, Annex 2 to Article VI, pages 103 - 105, lists the information the State Party includes in the declaration.

82 CD/961, Annex to Article VI, (vii), page 104.

83 CD/961, Appendix II, *Report On How To Define Production* Capacity, pages 157 - 159, and CD/713, CD/CW/WP.146, 14 July 1986, Japan, *Some Quantitative Aspects of a Chemical Weapons Convention*.

84 CD/961, Annex 2 to Article VI, paragraph 13, (viii), page 108.

site.[85] Inspection teams will examine equipment identified in the facility agreement to verify that the equipment is not misused to produce Schedule 1 chemicals. This may include the external aspects of the reaction vessel and its ancillary equipment as well as control equipment associated with the reaction system.[86]

To meet the verification aim of ensuring that the facility is not used to produce Schedule 1 chemicals, inspectors may evaluate the design of the facility for suitability to producing chemical warfare agents. Inspectors will compare the raw materials used as inputs and the configuration of equipment. As some chemical warfare agents have a synthetic production route similar to that for commercial chemicals, inspectors may consider the chemicals used on site related to how easily the production process can be converted to production of a chemical warfare agent.

Inspectors will select areas to observe, such as storage for feedstocks and final product, filling areas, or effluent handling areas. Inspectors may observe where the chemical feedstocks are delivered or the areas where the manipulative processes are performed on reactants.[87] Inspection teams also may consider feed lines to the reaction vessel to observe the mode of operation from reactors to other parts of the system.

In accordance with the facility agreement, inspection teams may take vapor, soil, liquid, and equipment wipe samples from production or process units or from stocks in storage.[88] Following the sampling plan, inspectors may take, for example, soil samples at loading areas, liquid samples from final products, or wipe samples from equipment. Inspectors will follow agreed procedures for handling samples to ensure the integrity of the samples and for transporting the samples if they are to be analyzed off site. On-site analysis may be performed with analytical instruments brought by inspection teams or, in some cases, with equipment supplied by the facility.

In addition to the types of verification measures mentioned above, inspection teams may be allowed to perform other inspection measures when the modalities of inspections are defined in a final CWC and identified in final facility agreements.

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85 The United States noted in CD/802 the difficulty of defining precisely what areas of a production site will be subject to routine inspections.

86 CD/961, Annex 2 to Article VI, paragraph 13, (iv), (vi), page 108.

87 CD/961, Annex 2 to Article VI, paragraph 13, (i), (ii) page 108.

88 CD/961, Model for Agreement, paragraph 6, page 164.

c. Installation Visit

Automatic process monitoring systems may be installed at Schedule 2 chemical facilities to supplement the on-site inspection regime. Equipment considered for this verification aim might combine in-line analytical instruments such as fiber-optic near-infrared, or on-line sampling instruments. [89]

Advance preparations for equipment procurement and installation may be necessary to coordinate process monitoring installation with facility operators. Instruments will need to be tested and certified before the monitoring system is activated. The IDA estimate considers a team of five persons on site for 5 days with 15 preparation and recovery days included to review requirements for installation of instruments.

d. Routine Inspections

The International Inspectorate will conduct routine inspections at all declared Schedule 2 chemical facilities. The timing and frequency of routine inspections will be determined by the characteristics of the facility, the type of activity the facility is involved in, and the risks that the facility poses for use in prohibited production. Schedule 2 chemical facilities will be selected for on-site inspection by a method to preclude predictability of when the inspection will occur.

Inspection team activities summarized above for initial inspections also will be carried out during routine inspections. Also during routine inspections, inspectors will evaluate whether any technological changes have been made since the facility agreement was developed and will perform regular maintenance of the monitoring system. Table I-6 summarizes the inspection framework for Schedule 2 facilities.

3. Schedule 3 Facilities

Schedule 3 chemical facilities are the final type of facility covered by Article VI. The verification provisions for Schedule 3 chemical facilities are outlined in Annex 3 to Article VI. These facilities, declared by the State Party, will be monitored by initial and annual data declarations submitted to the International Organization.[90]

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89 See Report of the Technical Group on Instrumentation for a discussion of possible equipment for this role, page 27 - 28.

90 CD/961, Article VI, paragraph 7, page 21, and Annex 3 to Article VI, pages 111 - 112.

State Parties will submit information on Schedule 3 chemicals that are produced, processed, or consumed by the industry of the State Party. Total amounts produced, processed, consumed, imported and exported in the previous year will be reported.[91] The declaration will contain information on each chemical by name and formula and by categories of final products or end use. Schedule 3 chemical facilities will be further identified by location, ownership or operational management, capacity, and approximate amount of production or consumption.[92]

It is expected that Schedule 3 chemical facilities will be monitored only if a specified threshold level is met for processing, production, or consumption. The draft text of the CWC now brackets a threshold quantity of 30 tons although a higher threshold has been discussed for some listed chemicals typically produced in large quantities.[93]

The verification regime for Schedule 3 chemical facilities does not include planned routine on-site inspections.

E. ANTICIPATED CATEGORIES OF ON-SITE INSPECTIONS

The preceding sections focused on the graded verification approach now outlined by draft text in the Chemical Weapons Convention. The verification regime of systematic and routine on-site inspections was described to match CWC verification aims for each type of facility. This on-site verification system is built on monitoring chemical activities that pose a risk to the objectives of the Convention, which are to ensure that chemical weapons are not produced. However, Conference on Disarmament participants and observers alike acknowledge that this elaborate verification system would nonetheless exclude many facilities of concern from on-site verification.

Examples of activities of concern are taken from Conference on Disarmament discussions. The proposed on-site inspection regime of the CWC would cover only a limited number of declared facilities, so that a large number of facilities would not be

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91 Under a final CWC, the total may be expressed as an exact figure or reported within a range. CD/961, Annex 3 to Article VI, footnote 1, page 111.

92 The definition of capacity requires further discussion. CD/961, Appendix II, *Report on How to Define 'Production Capacity,'* pages 157 - 159, contains material summarizing the results of discussions held at the Conference on Disarmament. The definition suggested would consist of a verbal part and a mathematical formula.

93 Higher thresholds for the dual purpose agents have been presented in informal discussions at the Conference on Disarmament. Also, CD/802, CD/CW/WP.186, 5 February 1988, The United States of America, *Thresholds for Monitoring Chemical Activities Not Prohibited by a Convention*, proposes that Schedule 3 chemical facilities of up to 30 tons a year be monitored by annual data declarations.

subject to any systematic international monitoring. In some cases, a State Party might not have to declare a single facility of their chemical industry.[94]

In addition, undeclared military and other facilities that could play a crucial role in clandestine chemical warfare activities would not be subject to routine on-site inspections. Even in facilities subject to routine inspections, chemical activities may go undetected.[95] Schedule 3 chemical facilities, for example, would be monitored by data declarations although the information submitted in these declarations would not be verified by on-site inspection.[96]

Moreover, the CWC verification system focuses on monitoring production, use or consumption of chemicals listed in the Schedules. Other facilities, which are relevant to the Convention because they are *capable* of producing Schedule chemicals, would not necessarily be covered by the inspection regime. For example, facilities processing non-toxic Schedule 2 chemicals would be subject to the routine inspection regime even when facility design and characteristics indicate that the facility is not capable of chemical warfare agent production. On the other hand, a facility with extensive safety features that could readily allow chemical warfare agent production might not be declared under the present regime of the CWC if that facility did not produce, process, or use a Schedule chemical.[97]

Under a final Chemical Weapons Convention this verification gap might be closed by on-site challenge inspections. Others argue that a system of anticipated inspections, referred to as "Spot Checks", "Ad Hoc Checks", or "Ad Hoc Inspections," should be included in the layered verification regimes of the CWC. The following sections summarize proposed on-site verification regimes to address the concerns mentioned above.

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94 CD/869, CD/CW/WP.210, 6 September 1988, Federal Republic of Germany, Working Paper, *Verification of Non-Production of Chemical Weapons, Ad Hoc Checks.*

95 CD/909, CD/CW/WP.232, 30 March 1989, United Kingdom of Great Britain and Northern Ireland, *Chemical Weapons Convention, Ad Hoc Inspections.*

96 CD/961, Annex 3 to Article VI, page 112, includes the footnote, "Some delegations consider that provision should be made for resort to an on-site 'spot-check' inspection, if required, to verify information supplied by a State Party. Other delegations believe that the provisions of Articles VII, VIII, and IX of the Convention are sufficient in this respect." Also, CD/698, CD/CW/WP.140, 6 February, Australia, states, "Data covering chemicals considered to pose less of a risk, and which may be produced by industry in very large amounts, should be subject to some type of 'spot check' to remove substantive doubts that may arise about compliance with the Convention or to provide reassurance to the international community that the provisions of the Convention are being observed."

97 CD/924, CD/CW/WP.251, 23 June 1989, Netherlands, *Report on a National Trial Inspection* and CD/925, CD/CW/WP.252, 23 June 1989, Netherlands.

1. Challenge Inspections

Costs associated with challenge inspections have not been included in our base case estimates. Until the substance and form of challenge inspections are developed further, cost estimates for challenge inspections have little firm foundation. Pointed interest in the "challenge procedure" mentioned under Article IX has not been translated into agreement on the characteristics, modalities, or scope of an on-site inspection.

The single reference to a "challenge procedure" in Article IX, *Consultations, Co-Operation, and Fact Finding*, states only that procedures for requesting a fact-finding mission "remain to be elaborated." A definition, "Challenge inspection means the inspection of a State Party requested by another State Party pursuant to Article IX, Part II,"[98] is given in an Addendum to Appendix I and is thus not now part of the draft text of the Convention. Consultations on challenge inspections have been blocked for inclusion as a document in Appendix I but are reported in Appendix II.[99]

At present, very little beyond conjecture can be used as a basis for resource estimates since the scope of inspections, the types of facilities affected, the location and size of inspected areas, the duration of inspections, the size of inspection teams, and the frequency of occurrence must all be considered variable and drawn from assumptions beyond the status or development of present negotiations at the Conference on Disarmament.

The main function of challenge inspections is to discourage breaches of the Convention from occurring in the first place by creating the likelihood of discovery. The challenge inspection is therefore understood by some as an exceptional "verification mechanism of last resort."[100] The Dutch delegation concluded that "the possibility of 'challenge' inspections has little bearing on the size of the inspectorate," and that ". . . the number of challenge inspections is likely to be relatively low. Hence, no permanent inspectors need to be designated for this task alone."[101]

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98 CD/961, Addendum to Appendix I, *Protocol on Inspection Procedures*, page 120.

99 CD/961, Appendix II, *Outcome of the Open-ended Consultations on Article IX, Part 2: On-Site Inspection on Challenge*, pages 185 - 187.

100 CD/715, United Kingdom of Great Britain and Northern Ireland, op. cit.

101 CD/445, 7 March 1984, The Netherlands, *Size and Structure of a Chemical Disarmament Inspectorate*, pages 5 and 10.

In any case, estimating resource requirements for challenge inspections will require treating challenge as an on-site inspection with specified duration of inspections and size of inspection teams. The approach would then permit exploration of the range of uncertain verification components. For example, if a challenge inspection is initiated to investigate the alleged use of chemical weapons, then resource requirements depend on battlefield conditions.[102] A challenge inspection at a commercial chemical facility or a military installation would lead to different requirements and would depend on the permitted scope of the inspection mandate.[103]

Required resources will depend on whether proposed limitations are agreed to in a final Convention.[104] A clearer picture of how challenge inspections may be limited could be used to develop a strawman and cost estimates of, for example, required resources for near-site or perimeter monitoring. Cost elements may then be linked to challenge inspections by defining issues of timing and duration, permitted inspection procedures, provisions for alternative measures, and arrangements for initiating a challenge inspection through bilateral consultations or multilateral fact -finding procedures.

2. Ad Hoc Verification

Ad Hoc inspections have been proposed as an additional means of on-site verification to complement planned routine and proposed challenge inspections. The primary concept of Ad Hoc inspections has been developed in working papers submitted to the Conference on Disarmament by the delegations from Australia, the Federal Republic of Germany and the United Kingdom of Great Britain and Northern Ireland.[105]

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102 The UN investigations by the Expert teams are an excellent source for resource determination. See, for example, Canada, *Handbook for the Investigation of Allegations of the Use of Chemical or Biological Weapons*. Also, CD/936, 21 July 1989, Norway, *Verification of Alleged Use of Chemical Weapons, A New Approach For Verification Procedures.*

103 CD/CW/WP.208, 26 August 1988, German Democratic Republic, *On-Site Inspection on Challenge, Outline Of A Manual For the Activities of Inspectors Conducting Inspections Under Article IX of the Convention*. CD/715, 15 July 1986, United Kingdom of Great Britain and Northern Ireland, *Chemical Weapons Convention: Verification and Compliance - The Challenge Element*. CD/966, CD/CW/WP.275, February 1990, Union of Soviet Socialist Republics, *Trial Challenge Inspection At A Military Facility.*

104 Proposed limitations on the challenge inspection mandate range from limitations on the obligatory "anywhere, anytime" concept, to limitations based on defined objective criteria for facilities, limitations on degrees of intrusiveness or access during inspections, and ultimately a "right of refusal."

105 CD/791, 25 January 1988, Federal Republic of Germany. CD/869, FRG, op.cit. CD/909, UK, op. cit. CD/698, Australia, op. cit.

Ad Hoc inspections are included in our cost estimates for the following reasons. Support for the adoption of some type of Ad Hoc verification system is substantial, and, from a cost perspective, should be accounted for since excluding Ad Hoc inspections would likely underestimate requirements measured in costs or inspection personnel. It has been estimated that a large number of facilities may be subject to Ad Hoc inspections.[106]

Ad Hoc inspections described in this section are extrapolated from Conference on Disarmament Working Papers and other source material. If Ad Hoc verification is adopted in a final Convention, inspections may differ greatly from what is outlined here. We have, however, attempted to remain consistent with the proposed character of Ad Hoc inspections (such as limited intrusiveness) and retained specific measures from different proposals to treat Ad Hoc verification as on-site inspections.

The rationale for a system of Ad Hoc verification draws from assumptions about the necessity of adding an additional layer of on-site inspections. Proposals for Ad Hoc verification include the following considerations: even under an effective verification regime a vast number of chemical capable facilities would not be monitored; while challenge inspections are intended to cover all undeclared facilities, challenge inspections are seen as a dramatic and confrontational political measure and "must be based on some *kind of evidence of non-compliance" that may be difficult to obtain.* Further, clandestine production is unlikely to occur in a declared facility if a clandestine location could be used for prohibited purposes.[107] The role, then, of Ad Hoc verification is to promote deterrence of illegal activities by broadening the declaration of chemical weapon related production capability, thereby creating a greater probability of detection through on-site inspection. While not a substitute for either routine or challenge inspections, Ad Hoc inspections may then build confidence in the CWC by proving to State Parties that other State Parties are complying with the Convention.

The verification objective of an Ad Hoc inspection is to verify that no prohibited activities are taking place at the facility. Ad Hoc inspections would be limited in scope and intrusiveness, as suggested by one approach, to limit investigation of legal activities and

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106 The size of the universe of facilities given by several sources ranges from 10,000 to 100,000. See CD/909, UK op.cit.

107 *Negotiating Chemical Disarmament*, Lecture at Kennedy School of Government, by Mr. Johan Molander, Deputy Head of the Delegation of Sweden to the Conference on Disarmament, 7 November, 1989.

thereby protect sensitive business information.[108] Therefore it may be possible to conclude the inspection in a short period of time to ascertain whether, at the time of the inspection, controlled chemicals, not reported for the facility, are being produced there. Investigations would proceed further only if undeclared production were detected.

Inspection team activities would be limited to verification methods related only to the purpose of the inspection. Thus, inspection teams may not be allowed to examine substances not listed in the Schedules or may be permitted to observe only specific design characteristics at the facility with the limited inspection goal of detecting illicit production. For example, when on-site inspections occur at facilities where baseline data has not been established, inspection teams may hold an opening conference with plant operators to review site maps and process diagrams for the facility and then determine which production unit within the facility to inspect. Inspectors might request a list of equipment[109] used in that production unit and select for examination equipment such as a reactors and ancillary equipment, waste and water outlets, storage areas, or contained safety areas.[110] An inspection also might be limited by only allowing on-site analysis with pre-agreed instruments.[111]

Ad Hoc inspections might be initiated by the Technical Secretariat or by a State Party under a system of passive quotas, or by a combination of both of the above.[112] One

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108 CD/869, FRG, page 3, op. cit., "By their nature ad hoc checks would not be very intrusive, their sole purpose being to ascertain whether, at the time of the check, substances listed in Annexes [1], [2] and [3] to Article VI and not reported for the facility in question are being produced there. Only if such an undeclared production is detected should further investigations to establish whether production is in amounts above declared thresholds be permitted."

109 Location of suggestive production may include considering in the aggregate equipment such as, chemical process equipment constructed of an alloy with a high nickel or tantalum content, or with linings suitable for use in a corrosive environment, pumps of valves designed for use with hazardous chemicals, activated carbon filter units and scrubber units capable of handling large volumes of air from ventilation systems, equipment designed for flourine, phosphorous, or sulphur analyses, inert gas generating units, double-walled piping, sensitive toxic detection and alarm systems, filling equipment for use with hazardous chemicals, and incineration or scrubbing equipment. CD/698, op. cit.

110 The Netherlands reported on a National Trial Inspection which, "as no facility attachment was worked out, the character of the trial inspection was ad hoc". Reported in CD/925, CD/CW/WP.252, 23 June, 1989, *An Attempt to Verify Non-Production in a Chemical Plant*. The inspection was conducted for "verification of non-misuse of relevant equipment". Some example inspector tasks have been taken from this trial inspection, although we have not followed the detailed approach explained therein. More importantly, to retain the idea of limited intrusiveness called for in other proposals, we have not described Ad Hoc inspections as a comprehensive approach that would, for example, give the inspection team full access to the facility.

111 CD/869, FRG, op. cit.

112 The FRG proposes that to ensure the routine character of Ad Hoc checks, facilities should be selected at random and that the International Inspectorate should not depend on information provided by other

way facilities might be selected for inspection, as proposed by the Federal Republic of Germany, would be for each State Party to submit a "National Registry" on the basis of an agreed definition of chemical industry. With this "picture of industry" describing facilities by name, ownership, location, orientation, and principal products, the International Inspectorate would randomly select facilities for inspection, perhaps by using a weighting factor that would, say, give on-site inspections at facilities producing organophosphorous compounds a higher priority than inspection at facilities producing less toxic compounds.[113] An alternative proposed by the British would give each State Party the right to initiate inspections by the Technical Secretariat. This quota system would distinguish Ad Hoc inspections from challenge inspections and would make access to the sites mandatory. Table I-7 summarizes the assumptions pertaining to Ad Hoc Inspections.

Table I-7. Ad Hoc Inspections

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY (YEAR)
• **Select Facilities** - consult National Registers - consider quota requests - apply guidelines for selection - consider facility characteristics • **Give Short Notice to Facility** • **Develop Access Agreement** • **Establish Accuracy of Registry Information** - validate facility by name, location operation, ownership, orientation and product categories • **VERIFY NON-PRODUCTION OF SCHEDULE CHEMICALS** - follow protocol for inspection - hold opening conference with facility operators, review site maps and process diagrams - select production unit to focus inspection activities - observe for undeclared production - limit intrusiveness by inspection methods - conduct visual inspection of relevant equipment and compare with industry applications (buildings, reactors, waste and water outlets, storage areas, and contained safety areas) - perform sample analysis for presence of a schedule chemical • **Terminate Inspection** - conclude inspection when non-production of schedule chemicals established	4	1	3	4	60

State Parties. The UK, however, proposes another alternative building on the provisions of the Stockholm Document: a quota system giving each State Party the right to make some number of requests for inspections (not specified) and would obligate each State Party to receive some number (not specified).

[113] CD/869, FRG, op. cit.

II. COST FACTORS

A. INTRODUCTION

A cost model was developed to calculate the level of effort required to implement verification provisions in the draft CWC and to address undetermined cost components of a final verification regime. The framework of on-site inspections and visits described in the preceding chapter was used to estimate resource requirements which were then used as data inputs to a cost model. The equations that define the cost model used to calculate totals for illustrative cases are presented in Appendix A. Resource estimates were varied in each case to yield alternative examples of final costs. The following paragraphs describe individual cost factors.

The cost to the United States is given in this paper as a percentage of total International Organization costs plus the cost of providing escorts for inspections in the United States.[1]

A direct labor cost for inspectors is calculated based on the frequency and duration of inspections and the size of inspection teams. An overhead factor is then applied to direct labor to compensate for additional costs to the International Organization to support on-site verification. Travel costs for inspection teams are added for all travel to inspection sites in five geographic regions identified in this paper.

The cost of sample analysis is included in our totals although this cost is not linked directly to a particular type of analytical equipment. These questions are being addressed in multilateral forums, but until there is a clearer understanding of the analytical capability to be utilized in off-site facilities or the type of analytical equipment to be brought by inspection teams, estimates must remain speculative.

Similarly, representative costs for capital equipment are listed at the end of this chapter. However, because information is unavailable for the type of monitoring equipment that will be utilized, the source of capitalization, or an appropriate amortization method, realistic costs for purchases of capital equipment could not be captured under the

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[1]CD/961, Article VIII, pages 23-25.

broad focus required by this study. The totals provided may be added to the totals in the illustrative cases, however, for a closer approximation of final requirements.

The analysis applies a variety of information sources. Because of the uncertainty in all of the cost data used, no rigorous indexing has been applied. All costs presented in this paper are in undiscounted, approximate 1990 dollars.

B. SAMPLING COSTS

Sampling cost will be determined by the number of samples analyzed per inspection. Therefore, sample analysis is added to our inspection costs as an additional cost component for each type of on-site verification (Table II-1).

Table II-1. Inspections and Sample Analysis

TYPE OF INSPECTION	FACILITY
• Initial Inspection	Storage, Destruction Chemical Weapon Production Schedule 1 ad 2
• Permanent presence	Storage (Interim) Destruction (Interim) Destruction (Active Period)
• Routine and Periodic Inspections	Storage Destruction Chemical Weapon Production Schedules 1 and 2

The number of samples and the cost to analyze samples are derived from information from the Arms Control and Disarmament Agency (ACDA), the National Trial Inspections, and the US Army. Sample analysis cost varies from $800 to $4,000, depending on the type of sample (vapor, solid, liquid or equipment wipe samples); the purpose of analysis (for example, verifying a known homogeneous sample or identifying the components of an unknown heterogeneous sample); and the required analytical equipment (such as GC/MS-gas chromatograph/mass spectrometer). We use a value of $2,000 for each sample taken for off-site analysis; however, this estimate does not cover the cost of transporting samples to analytical facilities, if necessary.

C. TRAVEL COSTS AND DISTRIBUTION OF INSPECTIONS

We distribute inspections globally by dividing the world into five regions, as shown in Table II-2. Facilities subject to on-site inspections are distributed among these

five regions, and commercial airline fares are added for the arrival destinations, or gateway cities, in each region. Travel costs used in our model are standard economy round trip rates from Geneva Switzerland to the arrival cities listed in Table II-3.[2]

Table II-2. Regions for Distribution of Facilities

North/South America
Eastern Europe/USSR
Western Europe
Middle East/Africa
Asia

Table II-3. Gateway Cities and Commercial Air Fares

North/South America-- Washington Dulles, USA	$2214
Eastern Europe/USSR-- Moscow, USSR	$1300
Western Europe-- Brussels, Belgium	$500
Middle East/Africa-- Amman, Jordan	$1427
Asia-- Tokyo, Japan	$4008

Calculated costs reflect the fact that the number of facilities will change over time and that both the number and location of destruction and storage facilities will vary over the 10-year destruction period. To meet elimination requirements of the Convention, destruction facilities will have to come on line for active destruction periods. Then, as the CWC is implemented, storage facilities will be closed out and production facilities will be eliminated.

The global distribution of commercial chemical facilities that produce, process, and consume Schedule 2 chemicals is largely unknown. Therefore, an estimate of 20 US Schedule 2 chemical facilities is used as a starting point to roughly approximate a world industry allocation suggested by the Chemical Manufacturers Association and other sources (see Table II-4).

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2 Business class fares may be considered appropriate for long distance flights. Round Tip fares would increase as follows: Washington, DC, USA - $2548 (1274 increase); Moscow, USSR - $1730 (430 increase); Brussels, Belgium - $842 (342 increase); Amman, Jordon - $2060 (633 increase); and Tokyo, Japan - $9050 (5042 increase).

Table II-4. Allocation of Facilities

	SCHEDULE 1	SCHEDULE 2	AD HOC
United States/NA+SA	3	20	170
Eastern Europe/USSR	5	20	170
Western Europe	8	20	170
Middle East and Africa	10	5	45
Pacific and Asia	10	5	45

Our approach to calculating travel costs for Ad Hoc inspections accommodated a large number of inspections without calculating separate travel costs for each individual inspection. Our estimates assume that inspection teams are assigned to a region for an extended period of time. In the base case, Ad Hoc inspections are counted as 12 annual inspections in each region over a period of 30 days. This approach recognizes that inspection teams will actually conduct many separate inspections in that same region but will not return to a central location each time. An additional $20,000 is then added to each 30-day period to cover travel costs within regions.

A worldwide allocation of facilities similar to the Schedule 2 allocation was used to assign Ad Hoc inspections to geographic regions. A total of 600 inspections[3] is allocated to the five regions, resulting in 170 inspections in 3 of the 5 regions and 45 in each of the other 2 regions. In regions where 170 inspections are allocated, we include the cost of 2 inspection teams (8 inspectors) conducting several inspections but returning to a central location only 12 times instead of 170 times. In regions where 45 inspections are allocated, we include the cost of 1 inspection team (4 inspectors) in the region. In regions allocated 170 inspections, there is a significant cost differential tween 12 round trip travel fares for two teams of eight inspectors and 170 round trip travel fares for each team of four inspectors.[4]

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3 The estimated 600 Ad Hoc inspections per year assumes that a quota of ten requests for Ad Hoc Inspections are assigned to sixty State Parties. Absent firm data, 600 Ad Hoc inspections was used as a compromise among numbers provided in our discussions ranging from 25 to 1800. Six hundred may be seen as a large number if the number of Ad Hoc inspections conducted is driven by a limited budget and by contrast, viewed as a small number relative to the number of facilities defined as "chemical weapon capable."

4 As indicated by this example, considerable cost savings and a more efficient use of personal time could be achieved by establishing regional nodes apart from a Geneva- or Vienna-based headquarters. The IAEA has, for example, two field offices in Toronto, Canada and Tokyo, Japan, to serve major areas of safeguarded facilities.

D. NUMBER OF FACILITIES

The number of facilities subject to on-site inspection and the permanent presence of an inspector can only be estimated.[5] The number of facilities to be monitored by the International Organization cannot be calculated with any degree of precision until the number of State Parties to the final Convention is known and until those Parties have provided data on their chemical industry to the International Organization.

1. Storage Facilities

Thirty-eight storage facilities are counted in our base case estimates. Nine of these storage facilities are US sites at the following locations: Umatilla, Oregon; Tooele, Utah; Pueblo, Colorado; Pine Bluff Arsenal, Arkansas; Newport Army Ammunition Plant, Indiana; Lexington Blue Grass, Kentucky; Anniston, Alabama; Aberdeen, Maryland; and Johnston Island, Pacific. Based on an unclassified Defense Intelligence Agency publication, nine storage facilities are are estimated for the Soviet Union.[6] Twenty additional storage facilities are included for reported possessor states.[7] No storage facilities were included for the Federal Republic of Germany since it is assumed that chemical weapons will be removed from there before a multilateral convention enters into force. Table II-5 displays the number of storage facilities assumed to exist in each region as a function of time after entry into force (EIF) of the Convention. The numbers decrease over time to reflect the closure of storage facilities as weapons stocks are destroyed. No storage facilities are assumed to exist beyond 10 years after EIF.

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5 The Netherlands submitted data on their chemical industry in CD/CW/WP.203 of 19 July 1988. In CD/828, 12 April 1988, *Provision of Data Relevant to the Chemical Weapons Convention*, the Federal Republic of Germany provided an outline for the submission of essential data. As of last year, only a few nations, including the German Democratic Republic (CD/871, CD/CW/WP.212, 12 September 1988) and Austria (CD/CW/WP.238, 10 April 1989) had submitted data on their chemical industry. Our calculations were completed before we received data provisions from Japan (CD/CW/WP.281, 16 March 1990), Hungary (CD/969, CD/CW/WP.277, 19 February 1990) and Sweden (CD/CW/WP.280, 16 March 1990).

6 Defense Intelligence Agency, *Soviet Chemical Weapons*, 1985.

7 See, for example, the testimony of CIA Director William Webster in *Testimony before the Senate Committee on Foreign Relations*, March 1, 1989, page 29: "Currently we believe that as many as 20 countries may be developing chemical weapons, and we expect this trend to continue, despite ongoing multilateral efforts to stop their proliferation." An estimate of 20 possessor states has been repeated frequently by US officials, including President Bush and officials from the Arms Control and Disarmament Agency. Assistant Secretary of State for Politico-Military Affairs, Richard Clark, stated in September at the Government & Industry Conference on Chemical Weapons, "To the best of our information, there are 22 nations that have chemical weapons in their inventories, controlled by their military and ready for use."

Table II-5. Estimated Number of Operational Storage Facilities

Year following EIF	1	2	3	4	5	6	7	8	9	10
U.S.	9	9	8	5	2	2	2	2	2	2
E. Europe USSR	16	16	16	15	15	14	10	8	5	2
W. Europe	1	1	1	0	0	0	0	0	0	0
Middle East	8	8	7	7	6	5	4	3	2	1
Pacific	4	4	4	3	3	3	2	1	1	1

2. Destruction Facilities

Destruction facilities also are distributed across both time and geographic regions in our base case estimates (Table II-6). Nine US facilities are counted after EIF based on the US demilitarization plan. Additional destruction facilities are accounted for in the base case estimates by giving a year when other nations will have destruction facilities on line. For each year after EIF, the estimates show the number of destruction facilities assumed to be operating in each region. For example, 12 facilities are assumed to be operational in year 3 and 10 facilities in year 7. No destruction facilities are assumed to be operating beyond 10 years after EIF. The numbers of facilities shown in the table are aggregate numbers that do not reflect the opening and closing of individual facilities. Altogether, Table II-6 represents 34 individual facilities.

Table II-6. Estimated Number of Operational Destruction Facilities

Year following EIF	1	2	3	4	5	6	7	8	9	10
U.S.	2	2	7	7	4	0	0	0	1	1
E. Europe USSR	1	1	3	5	5	5	5	5	4	4
W. Europe	1	1	1	0	0	0	0	0	0	0
Middle East	0	0	1	2	3	3	3	3	3	3
Pacific	0	0	0	1	1	2	2	2	2	2

3. Chemical Weapon Production Facilities

Thirty-five facilities are counted in our base case estimate for chemical weapon production facilities (Table II-7). The United States has five facilities located at Aberdeen, Maryland; Muscle Shoals, Alabama; Newport, Indiana; Pine Bluff, Arkansas; and Rocky Mountain Arsenal, Colorado. Based on an unclassified DIA publication, 10 are counted for the Soviet Union.[8] An additional 20 are counted for the reported possessor states. In

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[8] DIA, Op. cit.

the table, these numbers decrease over time as production facilities are destroyed. No chemical weapon production facilities are assumed to exist after year 10.

Table II-7. Estimated Number of Operational Production Facilities

Year following EIF	1	2	3	4	5	6	7	8	9	10
U.S.	5	5	4	4	3	3	2	2	1	1
E. Europe USSR	14	14	14	13	10	7	6	5	4	3
W. Europe	1	1	1	1	1	0	0	0	0	0
Middle East	8	8	8	7	6	6	5	5	4	3
Pacific	7	6	5	4	3	3	2	2	2	1

4. Schedule 1 Chemical Facilities

As it now stands, the CWC will permit Schedule 1 chemical production and use for protective, research, and medical or pharmaceutical purposes. Thus 36 Schedule 1 facilities are counted in our base case estimates.

5. Schedule 2 Chemical Facilities

Seventy Schedule 2 chemical facilities are included in our base case estimates, as noted above (Section C) in the discussion on travel cost allocation. Information on the distribution and number of worldwide facilities is fragmented and contradictory. For example, if threshold considerations are adopted as proposed by the United States and others, only facilities that produce or use schedule chemicals above a 10-ton threshold will be subject to on-site inspections. Estimates made for thousands of US Schedule 2 facilities may not include this limiting consideration.[9] On the other hand, the estimate of 20 US Schedule 2 *production* facilities--offered by the Chemical Manufacturers Association, which represents 90 percent of US industry--may exclude a significant number of other chemical facilities that use but do not produce a schedule chemical. Including these facilities could increase the estimated number of facilities subject to inspection fivefold if the widely held view that there are five consumers for each producer is applied.[10] Yet,

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9 US Assistant Secretary of State for Politico-Military Affairs and head of the US Delegation to the Government & Industry Conference on Chemical Weapons (September 1989), Richard Clark, stated, "It'll be necessary for inspection of upwards of 3000 chemical plants in the United States alone and 10,000 chemical plants around the world."

10 A recent submission to the Conference on Disarmament included 16 Schedule 2 production facilities above the 10-ton threshold and an additional 65 processing and consuming companies. CD/CW/WP.281, 16 March 1990, Japan, *Provision of Data Relevant to the Chemical Weapons Convention*. Sweden reported only one production facility (the threshold amount was not specified) and 6 "import" companies (CD/CW/WP.280, 16 March 1990).

again, the threshold criteria may limit the actual number of facilities that will be inspected. The United States is investigating the number of facilities under a separate contractor study supported by the CMA.

E. MANPOWER AND OVERHEAD COSTS

The manpower estimates assume that individual inspectors are available to work 200 days a year based on 5-day workweeks with days subtracted for holidays, vacation, and sick leave. During the available 200 days, inspectors would conduct inspections, travel, and prepare inspection documentation. The annual salary per inspector is estimated to be $70,000 . UN pay scales for senior or technical personnel indicate that a grade P-5 (unmarried) stationed in Geneva receives an adjusted salary of $67,233. This salary may, however, be inadequate to recruit qualified personnel with the appropriate technical skills and experience necessary for the Inspectorate.[11]

Additional expenses for the International Organization are accounted for by using an overhead factor of three. This factor is based on available corporate overhead data for the Washington, D.C., area. Administering the organization will require technical staff to support a variety of functions, ranging from laboratory tasks to data management, as well as support staff and materials not related directly to inspections.[12] These costs are assumed to be included in overhead.

F. COSTS TO DoD AND THE US

DoD costs for escorts of international inspection teams are calculated by taking representative costs provided by the On-Site Inspection Agency (OSIA) for the Intermediate Nuclear Forces (INF) treaty. Typical OSIA estimates for INF were given as $50,000 for a 1-week inspection and $400,000 for a 1-year permanent presence at a facility.[13] These numbers were subjectively modified to fit the proposed CWC inspection framework; that is, escort costs are not calculated directly by the number of inspectors or escorts. An

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11 Resource implications for personnel requirements were gleaned from the following submission to the Conference on Disarmament: Canada, *Chemical Weapons Convention: Article VIII, Factors Involved in Determining Verification Inspectorate Personnel and Resource Requirements*, 21 March 1988. Another source, *Arms Control Verification Occasional Papers*, number 3, "International Atomic Energy Agency Safeguards as a Model for Verification of a Chemical Weapons Convention", edited by H. Bruno Schiefer and James F. Keeley (1989), reported that Canada is continuing to develop a quantitative model to estimate inspection responsibilities of the International Inspectorate.

12 One source suggested that a 1:1 ratio of inspectors to support staff may be required.

13 Travel costs are included.

overhead factor of 1.6, based on OSIA information, was added to the escort cost. The data from OSIA was used in the base case and is shown in Table II-8.

Table II-8. Escort Cost for the Base Case

OSI/OSV ESCORT	
15 day Storage Inventory	$100,000
5 day Routine Inspection or Installation Visit	$50,000
2 day Inspection	$10,000
AD HOC Escort	$100,000 a year
PERMANENT PRESENCE	
150 day Storage Facility Presence	$200,000
150 day Destruction Presence	$150,000
365 day Active Destruction Facility	$300,000

We have not included counterintelligence costs in our estimates, but such costs may be incurred for activities to protect sensitive communications links and for FBI surveillance.

The budget of the International Organization will be apportioned to State Parties in a manner that has yet to be determined. Proposals include applying United Nations funding rules and practices, allocating to each State Party a percentage equal to the inspection burden in that nation, or adopting a special financing mechanism such as that used in the safeguards system of the IAEA.[14] We have apportioned a 40 percent contribution to the US in our illustrative cases.[15] The sensitivity of this factor is discussed in Chapter III.

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14 The IAEA finances safeguards under a special regime and through extra-budgetary contributions. After an economic adjustment among the States, 36 states pay 98 percent of the expenses.

15 U.S. costs are given as 40 percent of total costs. The study team received estimates of the US contribution which ranged from 15 percent to 60 percent. Forty percent was chosen to accommodate proposals for allocating costs between administrative functions and operational expenses of the International Organization. Thus, the United States might contribute 25 percent to the international administrative functions and be required to contribute a higher percentage of the operational expenses since it is a State Party with a large stockpile destruction program and a large number of chemical facilities.

G. CAPITAL COSTS

1. Headquarters Buildings and Other Facilities

The International Organization will incur capital costs to establish buildings to house the Headquarters of the International Organization and a Central Laboratory. There may be additional requirements, including regional offices and laboratory facilities, as part of a final agreement. Yet at this time neither the location nor the extent of facility requirements can be forecast from available information. Costs will, however, be sensitive to location. For example, a building to support an Inspectorate staff of 600 personnel can be constructed in Northern Virginia for approximately $45 million, but construction costs can be expected to be higher in other locations such as Geneva or Vienna.

2. Equipment and Instrumentation

Equipment requirements depend on the inspection task, the type of sample, the degree of sensitivity needed for analysis, and the issues of reliability and portability. Required analytical equipment continues to be discussed in many venues internationally, and proposed equipment covers a broad range of possible technologies. Technologies considered range from available equipment, such as gas chromatographs and portable mass spectrometers, to possible future technology such as ultrasonics.

Because analytical tasks required by the CWC can be performed by different types of equipment and because conclusions for equipment requirements are tentative, we have not addressed specific equipment types for individual tasks or the capital requirements to purchase equipment. We have, however, provided representative costs of equipment packages so that they may be added to total costs.

a. Team Equipment

A recent report by the Technical Group on Instrumentation[16] outlined equipment related to analytical tasks for declared facilities. In Table II-9, we have shown the equipment related to the inspection framework for facilities and added equipment costs based on data provided by chemists, the US Army, and open literature.

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[16] CD/CW/WP.272, 22 January 1990, *Report of the Technical Group on Instrumentation.*

Table II-9. Representative Team Equipment Costs (Part 1 of 2)

STORAGE				
1 Standard Team Pkg		GC		$45,000
1 Standard Team Pkg		GC		$45,000
1 Standard Team Pkg		GC		$45,000
1 Supplemental Pkg		HPLC		$70,000
		GC/MS		$200,000
		IR		$65,000
		MS		$100,000
Total				$570,000
DESTRUCTION				
Each Facility	1	GC	@	$45,000
	x	15	=	$675,000
Subtotal			=	$675,000
Supplemental Pkg				
	1	HPLC	@	$70,000
	1	IR	@	$65,000
	1	GC/MS	@	$200,000
	1	MS	@	$100,000
Subtotal				$435,000
Total				$1,110,000
PRODUCTION				
1 Standard Team Pkg		GC		$45,000
1 Standard Team Pkg		GC		$45,000
1 Supplemental Pkg		MS		$100,000
		HPLC		$70,000
Total				$260,000

Note: GC = gas chromatograph; HPLC = high performance liquid chromatograph; GC/MS = gas chromatograph/mass spectrometer; IR = infra-red spectroscopy; MS = mass spectrometer.

Table II-9. Representative Team Equipment Costs (Part 2 of 2)

SCHEDULE 1			
1 Standard Team Pkg	GC	@	$45,000
1 Standard Team Pkg	GC	@	$45,000
1 Standard Team Pkg	GC	@	$45,000
1 Supplemental Pkg	MS	@	$100,000
	HPLC	@	$70,000
	IR	@	$65,000
	GC/MS	@	$200,000
Total			$570,000
SCHEDULE 2			
1 Standard Team Pkg	GC	@	$45,000
1 Standard Team Pkg	GC	@	$45,000
1 Standard Team Pkg	GC	@	$45,000
1 Standard Team Pkg	GC	@	$45,000
2 Supplemental Pkg	MS	@	$100,000
	HPLC	@	$70,000
	GC/MS	@	$200,000
Total			$920,000
GRAND TOTAL			$2,990,000

For each category of the inspection framework, we have listed a minimum equipment package and a supplemental equipment package for inspection of each type of facility. The equipment lists include gas chromatograph (GC), high performance liquid chromatograph (HPLC), mass spectrometer (MS), low-resolution mass spectrometer (LRMS), high-resolution mass spectrometer (HRMS), infrared spectroscopy (IR), and gas chromatograph-mass spectrometer (GC-MS). The cost of this equipment can then be added when final requirements are determined. The estimated total cost of equipment listed is $3 million.

b. Central Laboratory Equipment

Equipment also may be purchased to equip a central laboratory. Representative costs of central laboratory equipment are provided in Table II-10. The minimum cost for

instrumentation for a central laboratory has been estimated to be approximately $1 million; however, this estimate may be conservative if state-of-the-art instrumentation is selected.[17]

Table II-10. Representative Central Laboratory Equipment Costs

MS/MS	$350,000
NMR	$530,000
GC/MS	$200,000
Total	$1,080,000

Note: MS/MS = mass spectrometer/mass spectrometer;
NMR = nuclear magnetic resonance
GC/MS = gas chromatograph/mass spectrometer

c. Surveillance, Containment and Process Monitoring Equipment

As it now stands, the draft CWC relies heavily on the use of instrumentation to meet the verification objectives of continuous monitoring by surveillance and containment or monitoring through process control instrumentation. Until the unique characteristics of each facility are evaluated and developed in the separate facility agreements, cost estimates must remain tentative. Nonetheless, equipment cost data is presented to illustrate a range of potential costs. And while technical analysis of equipment for feasibility and availability criteria was beyond the scope of this task, we have assumed a constant cost of $250,000 per facility for a maximum of 213 facilities.

Representative costs for surveillance and containment equipment (video cameras, seals, intrusion detectors, and supporting equipment for satellite data transmission adapted for the CWC) were given in a working paper to the Conference on Disarmament in 1985.[18] The estimated 8 cameras and 12 intrusion detectors presented in the report would be inadequate, however, at a US chemical storage facility with more than 200 storage bunkers. On the other hand, much of the equipment described in CD/619 is used routinely for security at US storage sites.

The cost for one type of automatic monitoring system (which may not be appropriate for all types of facilities) for a commercial facility has been estimated at

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17 The Ministry For Foreign Affairs of Finland, Helsinki 1984, *Technical Evaluation of Selected Scientific Methods For The Verification of Chemical Disarmament*, pages 37 - 68. This range is supported by U.S. industry experience.

18 CD/619, 23 July 1985, Japan, *Application of (Nuclear) Safeguards Remote Verification Technology to Verification of a Chemical Weapons Convention.*

$250,000.[19] This system is listed in Table II-11. A total of 213 facilities is derived by adding storage (38), destruction (34), production (35), Schedule 1 (36) and Schedule 2 (70) as facilities that may require instrumentation.

Table II-11. Cost Estimate for Process Monitoring Equipment

Flow Measurement Instruments	$32,000.00
Collection Subsystem	$20,000.00
Analysis Subsystem	$50,000.00
Data-Processing Subsystem	$120,000.00
Installations and Other Services	$28,000.00
Total per facility	$250,000.00
Grand Total for 213 facilities	$53.25 million

d. Satellite Remote Monitoring Equipment

This section details the possible cost of a data monitoring system. The information presented here is taken from a report produced for the Arms Control and Disarmament Agency (ACDA)[20]. The cost of the remote monitoring system is sensitive to a number of considerations: the number of terminals, the requirements for geographic coverage, and the amount of data transmitted. The estimated cost of $37,690,000, presented in Table II-12, is based on a system surveying 213 facilities and designed to transmit both data and images. The actual cost to design, procure, and install such a system will undoubtedly be higher. The cost of data handling and review has yet to be determined, and information is unavailable on how the International Organization would store, retrieve, and use the results of remotely transmitted information.

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19 O.V. Perroni, SIPRI, "Possibilities For Automatic Monitoring of Chemical Products," *Non-Production by Industry of Chemical-Warfare Agents; Technical Verification Under a Chemical Weapons Convention*, Vol. 9, edited by S.J. Lundin, 1988, page 96 - 101. See also in this same publication, N. Kyriakopoulos and R. Mikulak, "Instrumented monitoring of the Chemical Industry Under a Chemical Weapons Ban."

20 CD/WP.268 1990, United States, *Data Collection System Requirements of Remotely Monitored Sensors Used in Chemical Warfare Treaty Verification AC87MC103-Task 2-1.*

Table II-12. Estimated Satellite Remote Monitoring System Cost

Design cost = $10,000/man month • (200 month base design time + (8 month/design time/site • 213 sites)) = 19,040,000

Cost = 2•($4,000,000/per hub) + (213/terminals • $50,000/per terminal) = 18,650,000

TOTAL COST = $37,690,000

e. Total Capital Cost

The total estimated capital cost is $140,010,000, as shown in Table II-13. If the US contributed 40 percent of the capital cost, its allocation would be $56 million. While the capital cost will vary with the location, size of buildings required, and the type and amount of equipment procured, the capital cost is probably the least sensitive of all costs to alternative assumptions regarding the inspection framework. The cases examined in Chapter III do not include the capital costs listed here.

Table II-13. Estimated Capital Costs (millions of dollars)

HQ Building	$45.00
Team Instrumentation	$2.99
Laboratory Instrumentation	$1.08
Facilities Instrumentation	$53.25
Satellite Network	$37.69
	$140.01

III. RESULTS

A. INTRODUCTION

This chapter combines the inspection framework of Chapter I and the cost factors outlined in Chapter II to present estimates for a base case and eight other illustrative cases. The cost cases illustrate the impact of using different assumptions for key verification components like the frequency of inspections or the size of inspection teams. The cost model varies the uncertain resource requirements to show alternatives. As a further step, the sensitivity of individual data inputs is demonstrated by giving the impact on total cost of a single or a combined input change. Capital costs for resource requirements are not added to the example totals, but are included as an example.

B. CASE RESULTS

1. Base Cost Case Estimates
International Cost: $770 million for 15 years
Cost to US: $363 million for 15 years

The annual cost for the international base case is shown in Figure III-1. The breakout of US costs by year is shown in Figure III-2. The base case follows the on-site inspection framework, and Tables III-1 through III-7 restate that data as a reference to compare with changes made in other cases. For all the other cases, any changed data inputs are presented in bold text. Figure III-3 compares the annual cost of the base case for the International Organization and the United States. Note that the US costs are more than 40% of the international costs because of the amount of US resources devoted to escort.

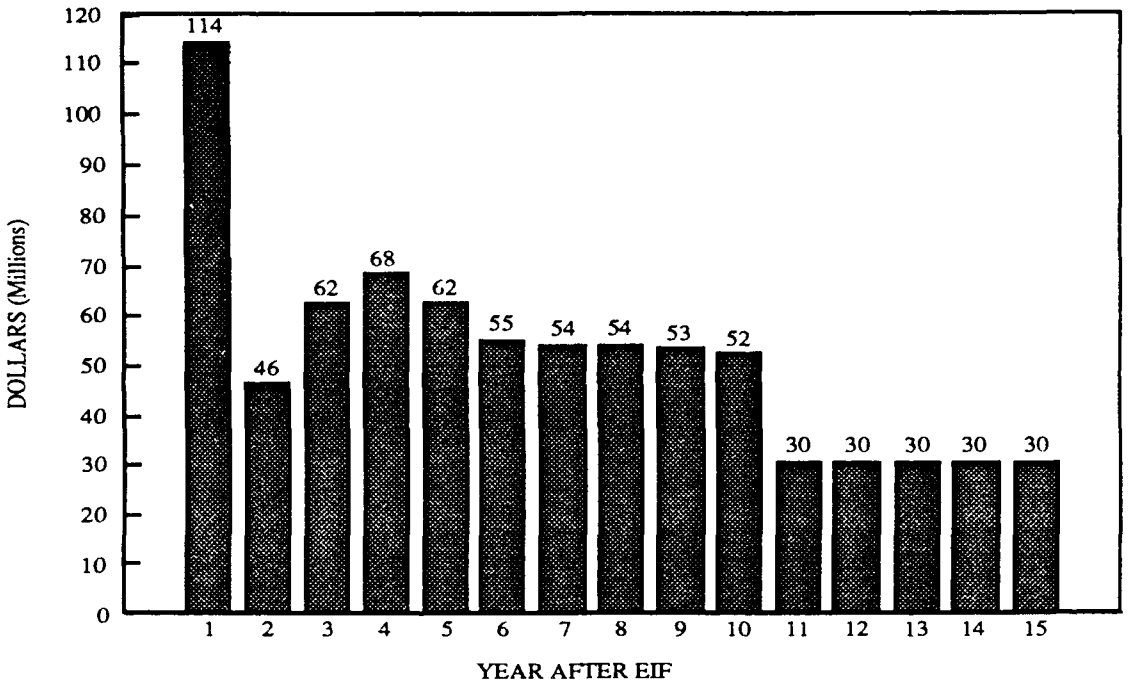

Figure III-1. International Base Case Cost

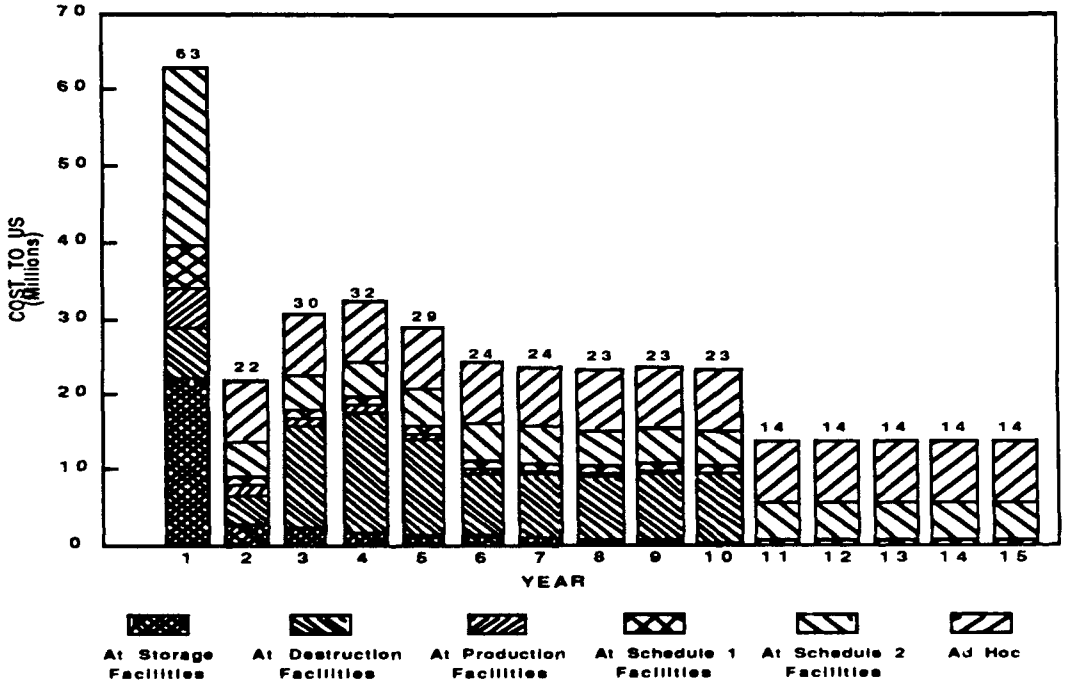

Figure III-2. Base Case US Cost Profile

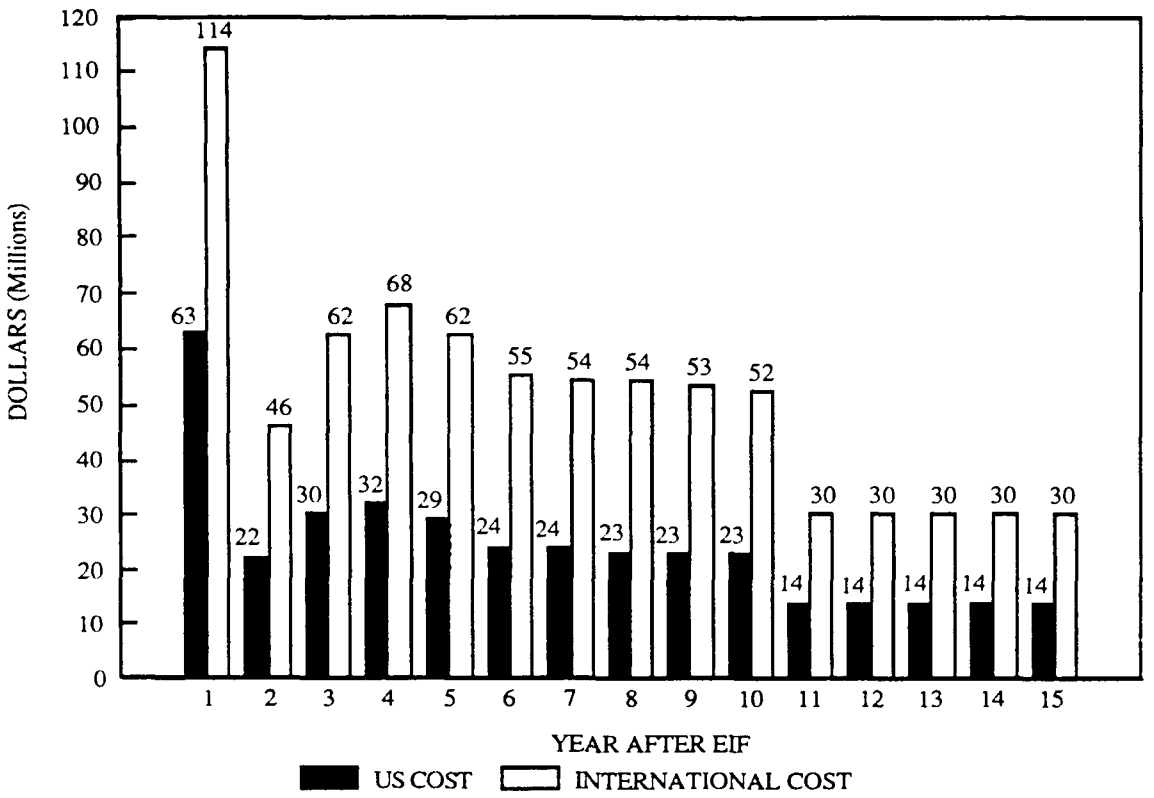

Figure III-3. Cost Profiles Base Case: US vs. International Organization

Table III-1. Base Case Storage Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	15	10	25	1
PERMANENT PRESENCE	4	150	-	150	1
INSTALLATION VISIT	5	5	10	15	1
ROUTINE INSPECTION	6	5	8	13	1/YR
CLOSEOUT INSPECTION	2	2	8	10	1

FACILITIES

Year	1	2	3	4	5	6	7	8	9	10
US	9	9	8	5	2	2	2	2	2	2
E. Europe USSR	16	16	16	15	15	14	10	8	5	2
W. Europe	1	1	1	0	0	0	0	0	0	0
Middle East/Africa	8	8	7	7	6	5	4	3	2	1
Pacific/Asia	4	4	4	3	3	3	2	1	1	1

Table III-2. Base Case Destruction Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	15	25	1
PERMANENT PRESENCE	4	150	--	150	1
INSTALLATION VISIT	5	5	15	20	1
INSPECTIONS	4	365	0	365	1
CLOSEOUT INSPECTION	2	2	8	10	1

FACILITIES

Year	1	2	3	4	5	6	7	8	9	10
US	2	2	7	7	4	0	0	0	1	1
E. Europe USSR	1	1	3	5	5	5	5	5	4	4
W. Europe	1	1	1	0	0	0	0	0	0	0
Middle East/Africa	0	0	1	2	3	3	3	3	3	3
Pacific/Asia	0	0	0	1	1	2	2	2	2	2

Table III-3. Base Case Production Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	10	20	1
CLOSURE INSP. ION (After 3 Months EIF)	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	4	2	8	10	1/YR
ELIMINATION INSPECTIONS	4	2	8	10	2/YR
CLOSEOUT INSPECTIONS	2	1	5	6	1

FACILITIES

Year	1	2	3	4	5	6	7	8	9	10
US	5	5	4	4	3	3	2	2	1	1
E. Europe USSR	14	14	14	13	10	7	6	5	4	3
W. Europe	1	1	1	1	1	0	0	0	0	0
Middle East/Africa	8	8	8	7	6	6	5	5	4	3
Pacific/Asia	4	4	4	3	3	3	2	2	2	1

Table III-4. Base Case Schedule 1 Chemical Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
SCHEDULE 1					
INITIAL INSPECTION	6	8	10	18	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTION	2	2	8	10	1/YR

FACILITIES

United States/NA+SA	3
Eastern Europe/USSR	5
Western Europe	8
Middle East/Africa	10
Pacific/Asia	10

Table III-5. Base Case Schedule 2 Chemical Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL VISIT	6	4	10	14	2
INITIAL INSPECTION	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	6	2	8	10	1/YR

FACILITIES

United States/NA+SA	20
Eastern Europe/USSR	20
Western Europe	20
Middle East/Africa	5
Pacific/Asia	5

Table III-6. Base Case Ad Hoc Inspections

INSPECTIONS

ACTIVITY	PERSONNEL	TIME-ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
• VERIFY NON-MISUSE OF CW CAPABLE EQUIPMENT	4	1	3	4	600/YR

LOCATIONS

United States/NA+SA	170
Eastern Europe/USSR	170
Western Europe	170
Middle East/Africa	45
Pacific/Asia	45

Table III-7. Base Case Cost Factors

Available work days per inspector	200
US fractional contribution to the International Organization	40%
Overhead factor for the International Organization	3
US overhead factor for inspection support	1.6
Annual direct cost per inspector	$70,000
Cost to analyze a sample	$2,000
Transportation cost	
NA/SA	$2,214
EEUR/USSR	$1,300
WEUR	$500
ME/Africa	$1,427
PAC/Asia	$4,000
Time horizon	EIF through 15th year

2. Cost Case 1: Base Case Data with Ad Hoc Inspections Increased From 600 Per Year to 1,200 Per Year
International Cost: $1052 Million for 15 years
Cost to the US: $475 Million for 15 years

In Case 1, all data inputs from the base case are retained, but the number of Ad Hoc inspections is doubled from 600 per year to 1,200 per year. This increases the number of Ad Hoc inspections for 14 (years 2-15) years by 8,400 and increases US costs by $112 million. Table III-8 shows the input change. Figure III-4 compares the US for the base case and Case 1.

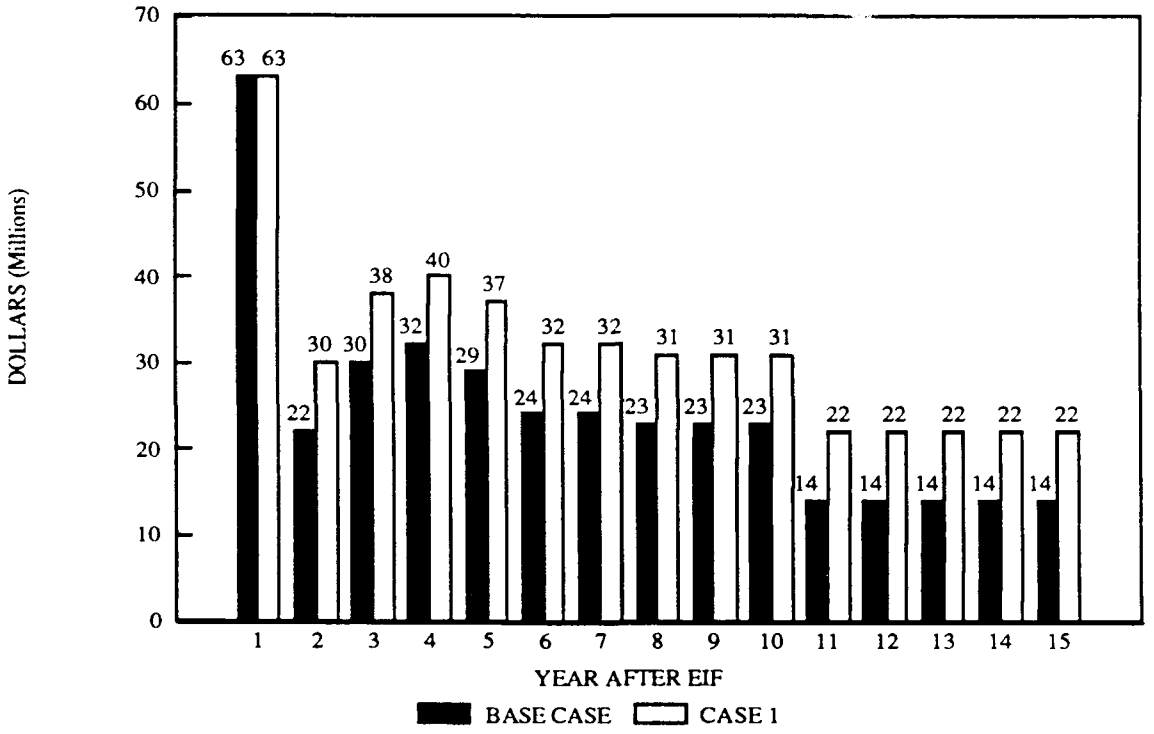

Figure III-4. Case 1 (Doubled Ad Hoc Inspections) vs. Base Case: US Costs, Escorts Included

Table III-8. Case 1 Input Changes

AD HOC INSPECTIONS	Base = 600	Case 1 = 1200
United States/NA+SA	170	340
Eastern Europe/USSR	170	340
Western Europe	170	340
Middle East/Africa	45	90
Pacific/Asia	45	90

3. Cost Case 2: Base Case Data with Routine Inspections Doubled
International Cost: $918 million for 15 years
Cost to the US: $464 million for 15 years

Case 2 retains the base case data inputs but increases the frequency of routine on-site inspections as shown in Tables III-9 and III-10. On-site inspections for storage, production, and Schedule 1 & 2 chemical facilities are doubled in years 2 through 15 after the Convention enters into force.

Case 2 increases the base case estimates to the United States from $363 million to $464 million as shown in Figure III-5.

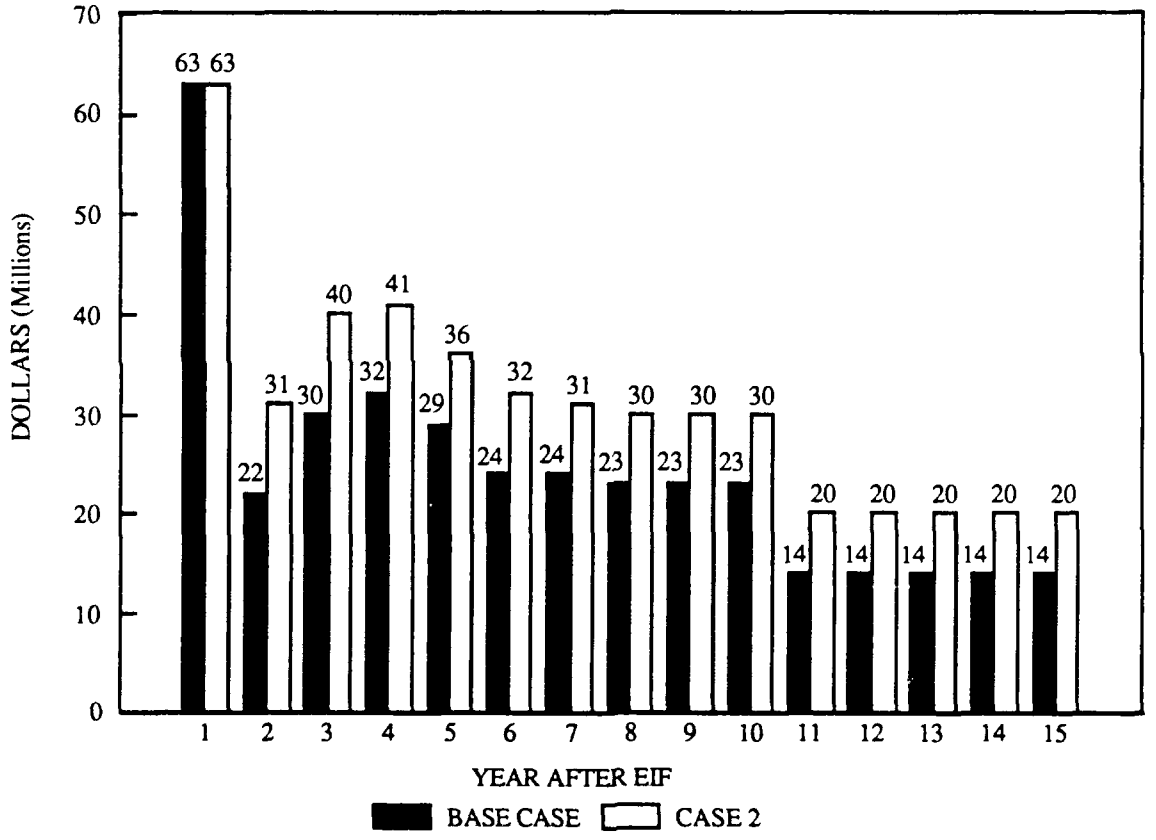

Figure III-5. Case 2 (Doubled Routine Inspections) vs. Base Case: US Costs, Escorts Included

Table III-9. Case 2 Changes

INSPECTIONS AT STORAGE FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	15	10	25	1
PERMANENT PRESENCE	4	150	-	150	1
INSTALLATION VISIT	5	5	10	15	1
ROUTINE INSPECTION	6	5	8	13	2/YR
CLOSEOUT INSPECTION	2	2	8	10	1

INSPECTIONS AT DESTRUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	15	25	1
PERMANENT PRESENCE	4	150	--	150	1
INSTALLATION VISIT	5	5	15	20	1
INSPECTIONS	4	365	0	365	1
CLOSEOUT INSPECTION	2	2	8	10	1

INSPECTIONS AT CHEMICAL WEAPONS PRODUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	10	20	1
CLOSURE INSPECTION (After 3 Months EIF)	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	4	2	8	10	2/YR
ELIMINATION INSPECTIONS	4	2	8	10	4/YR
CLOSEOUT INSPECTIONS	2	1	5	6	1/YR

Table III-10. Case 2 Changes

INSPECTIONS AT SCHEDULE 1 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
SCHEDULE 1					
INITIAL INSPECTION	6	8	10	18	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTION	2	2	8	10	2/YR

INSPECTIONS AT SCHEDULE 2 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL VISIT	6	4	10	14	2
INITIAL INSPECTION	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	6	2	8	10	2/YR

AD HOC INSPECTIONS

ACTIVITY	PERSONNEL	TIME-ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
• VERIFY NON-USE OF CW CAPABLE EQUIPMENT	4	1	3	4	600/YR

4. Cost Case 3: Base Case with Larger Inspection Teams
International Cost: $1298 million for 15 years
Cost to the US: $572 million for 15 years

Case 3 increases the number of inspectors for each inspection (except teams for installation visits) by a factor of between 1.6 to 2. Input changes are shown in bold in Tables III-11 and III-12, and the annual costs are presented in Figure III-6.

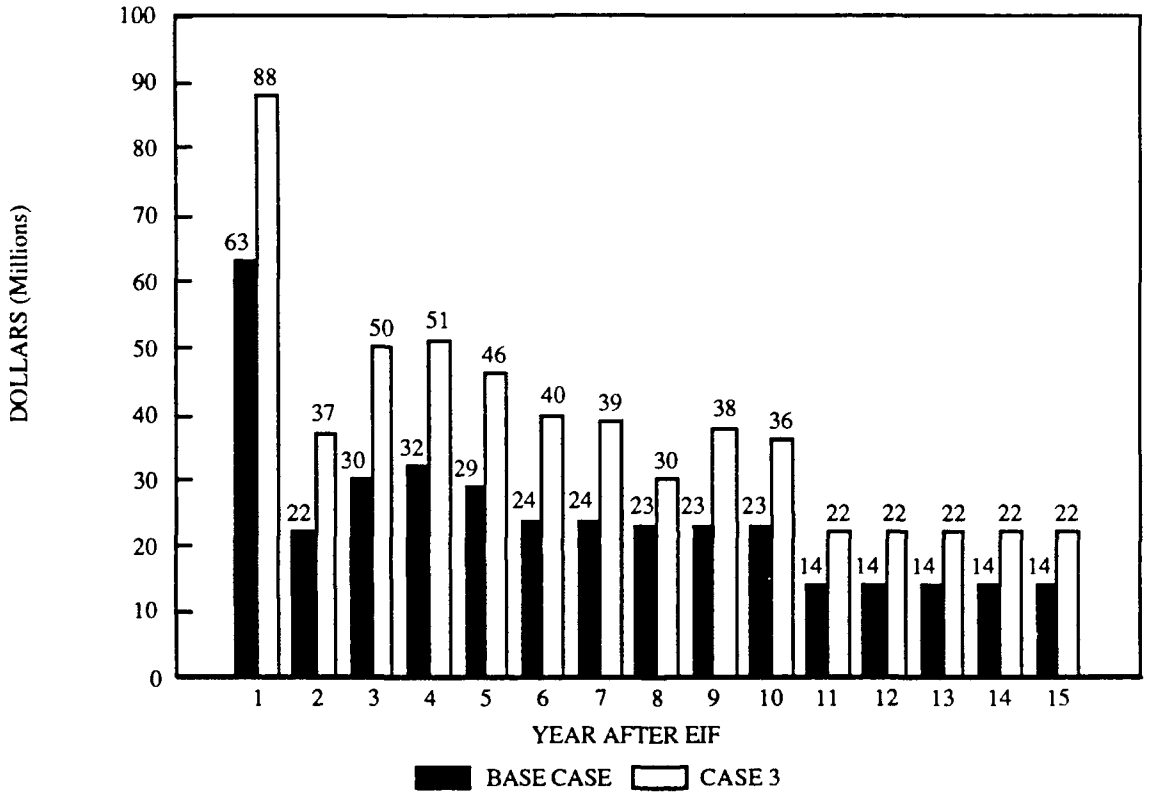

Figure III-6. Case 3 (Larger Inspection Teams) vs. Base Case: US Costs, Escorts Included

Table III-11. Case 3 Changes

INSPECTIONS AT STORAGE FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	10	15	10	25	1
PERMANENT PRESENCE	8	150	-	150	1
INSTALLATION VISIT	5	5	10	15	1
ROUTINE INSPECTION	10	5	8	13	1/YR
CLOSEOUT INSPECTION	4	2	8	10	1

INSPECTIONS AT DESTRUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	10	10	15	25	1
PERMANENT PRESENCE	8	150	--	150	1
INSTALLATION VISIT	5	5	15	20	1
INSPECTIONS	8	365	0	365	
CLOSEOUT INSPECTION	4	2	8	10	1

INSPECTIONS AT CHEMICAL WEAPONS PRODUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	10	10	10	20	1
CLOSURE INSPECTION (After 3 Months EIF)	10	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	8	2	8	10	1/YR
ELIMINATION INSPECTIONS	8	2	8	10	2/YR
CLOSEOUT INSPECTIONS	4	1	5	6	1/YR

Table III-12. Case 3 Changes

INSPECTIONS AT SCHEDULE 1 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
SCHEDULE 1					
INITIAL INSPECTION	10	8	10	18	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTION	4	2	8	10	1/YR

INSPECTIONS AT SCHEDULE 2 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL VISIT	10	4	10	14	2
INITIAL INSPECTION	10	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	10	2	8	10	1/YR

AD HOC INSPECTIONS

ACTIVITY	PERSONNEL	TIME-ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
• VERIFY NON-MISUSE OF CW CAPABLE EQUIPMENT	8	1	3	4	600/YR

5. Cost Case 4: Base Case with Quarterly Inspections
International Cost: $1238 million for 15 years
Cost to the US: $628 million for 15 years

Case 4 increases the frequency of routine on-site inspections from once a year to four times a year as shown in Tables III-13 and III-14. Figure III-7 compares the cost to the US for the base case and Case 4.

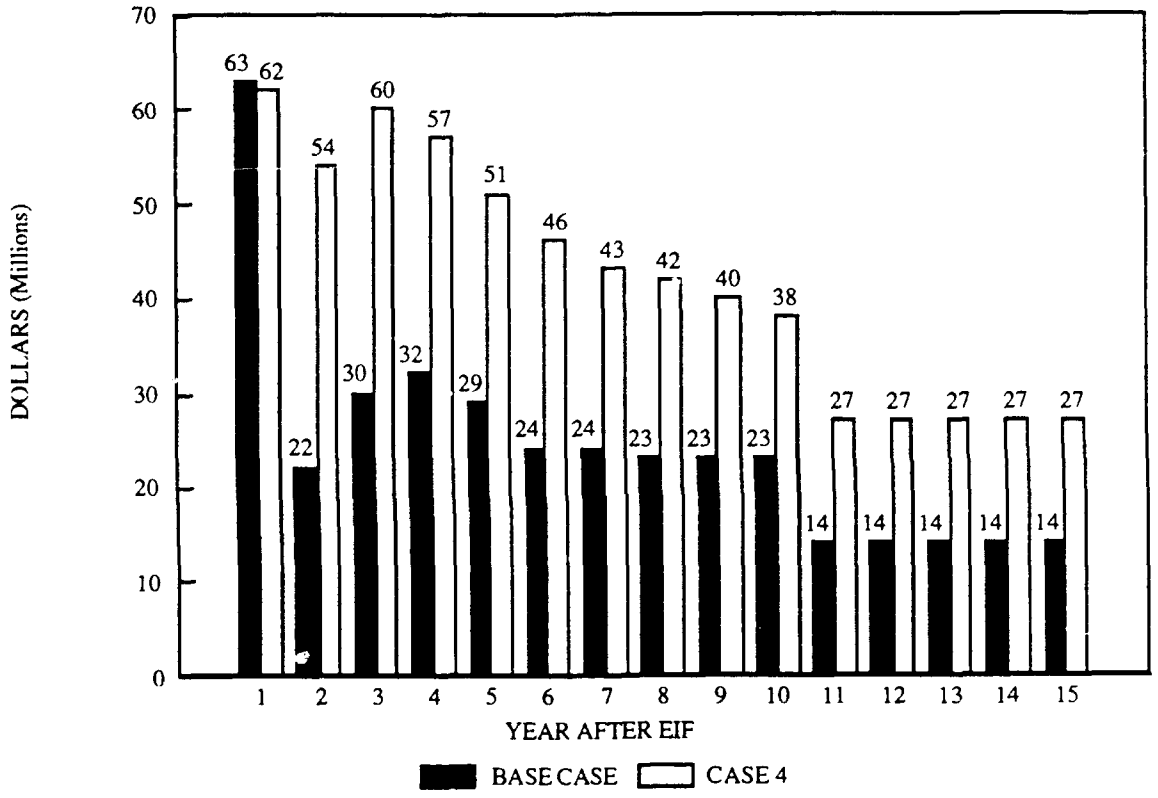

Figure III-7. Case 4 (Quarterly Routine Inspections) vs. Base Case: US Costs, Escorts Included

Table III-13. Case 4 Changes

INSPECTIONS AT STORAGE FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	15	10	25	1
PERMANENT PRESENCE	4	150	-	150	1
INSTALLATION VISIT	5	5	10	15	1
ROUTINE INSPECTION	6	5	8	13	4/YR
CLOSEOUT INSPECTION	2	2	8	10	1

INSPECTIONS AT DESTRUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	15	25	1
PERMANENT PRESENCE (Interim)	4	150	--	150	1
INSTALLATION VISIT	5	5	15	20	1
(ACTIVE DESTRUCTION)	4	365	0	365	1
CLOSEOUT INSPECTION	2	2	8	10	1

INSPECTIONS AT CHEMICAL WEAPONS PRODUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	10	20	1
CLOSURE INSPECTION (INITIAL)	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	4	2	8	10	4/YR
• ELIMINATION INSPECTIONS	4	2	8	10	8/YR
• CLOSEOUT INSPECTIONS	2	1	5	6	1/YR

Table III-14. Case 4 Changes

INSPECTIONS AT SCHEDULE 1 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
SCHEDULE 1					
INITIAL INSPECTION	6	8	10	18	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTION	2	2	8	10	4/YR

INSPECTIONS AT SCHEDULE 2 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL VISIT	6	4	10	14	2
INITIAL INSPECTION	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	6	2	8	10	4/YR

AD HOC INSPECTIONS

ACTIVITY	PERSONNEL	TIME-ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
• VERIFY NON-REPORTED PRODUCTION OF SCHEDULE CHEMICALS	4	1	3	4	600/YR

6. Cost Case 5: Base Case with Quarterly Routine Inspections and 1,200 Ad Hoc Inspections
International Cost: $1520 million for 15 years
Cost to US: $741 million for 15 years

Case 5 increases routine on-site inspections to four times a year and doubles the number of ad hoc inspections from 600 a year to 1,200. US costs are compared in Figure III-8.

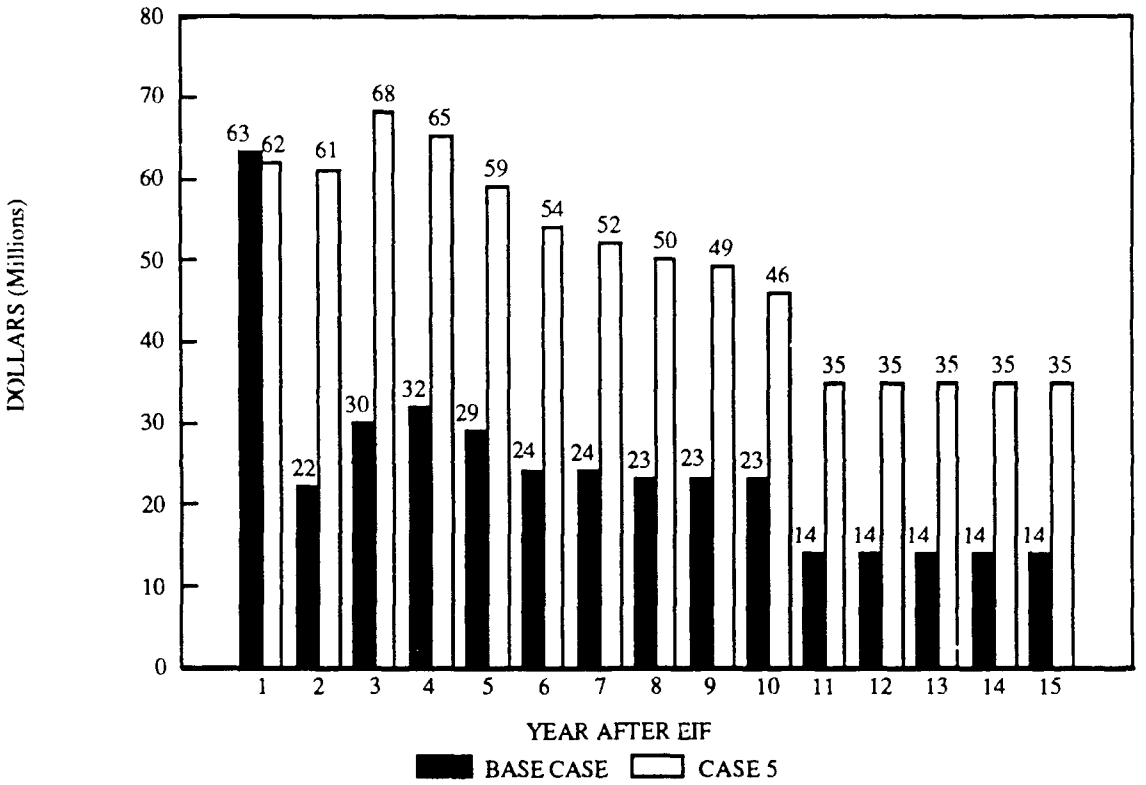

Figure III-8. Case 5 (Quarterly Routine Inspections Plus Doubled Ad Hoc Inspections) vs. Base Case: US Costs, Escorts Included

7. Cost Case 6: Base Case with Biennial Routine Inspections
International Cost: $628 million for 15 years
Cost to US: $305 million for 15 years

Case 6 reduces the frequency of routine on-site inspections to every other year as shown in Tables III-15 and III-16. See Figure III-9 for annual US costs.

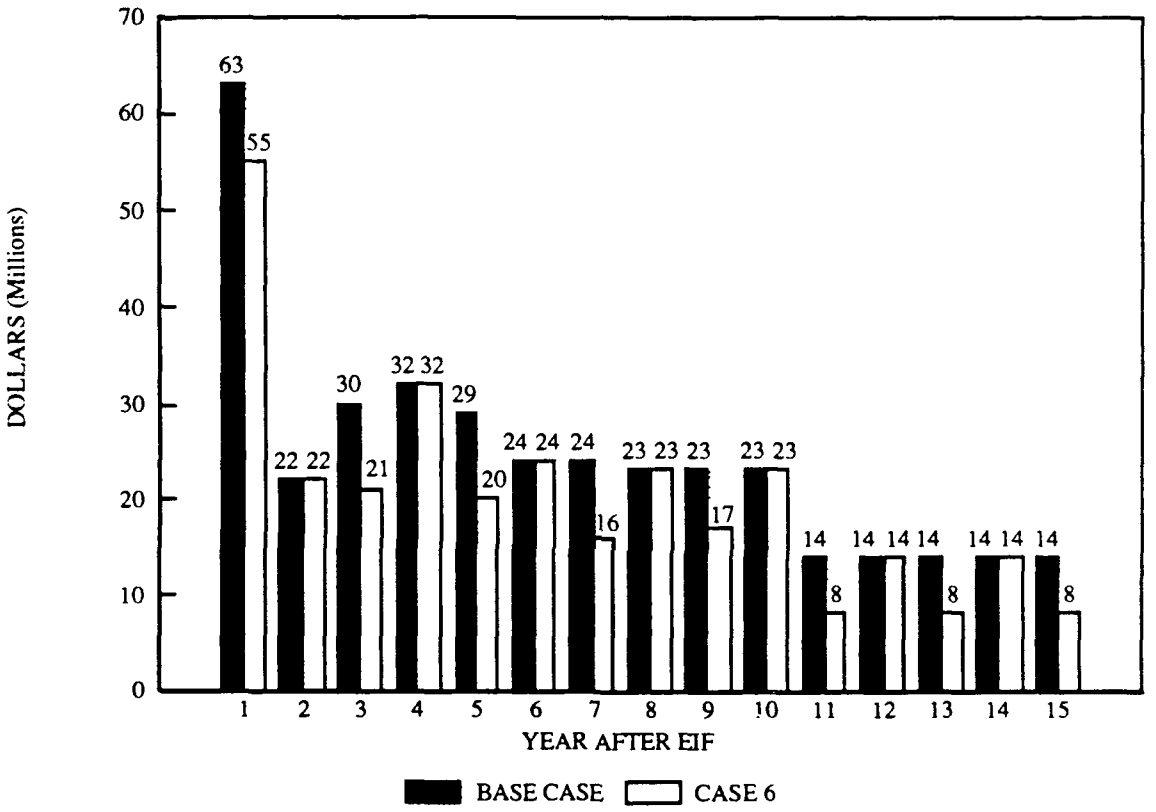

Figure III-9. Case 6 (Biennial Routine Inspections) vs. Base Case: US Costs, Escorts Included

Table III-15. Case 6 Changes
(B = every other year)

INSPECTIONS AT STORAGE FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	15	10	25	1
PERMANENT PRESENCE	4	150	-	150	1
INSTALLATION VISIT	5	5	10	15	1
ROUTINE INSPECTION	6	5	8	13	B
CLOSEOUT INSPECTION	2	2	8	10	1

INSPECTIONS AT DESTRUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	15	25	1
PERMANENT PRESENCE	4	150	--	150	1
INSTALLATION VISIT	5	5	15	20	1
INSPECTIONS	4	365	0	365	1
CLOSEOUT INSPECTION	2	2	8	10	1

INSPECTIONS AT CHEMICAL WEAPONS PRODUCTION FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	10	20	1
CLOSURE INSPECTION (After 3 Months EIF)	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	4	2	8	10	B
ELIMINATION INSPECTIONS	4	2	8	10	B
CLOSEOUT INSPECTIONS	2	1	5	6	1/YR

Table III-16. Case 6 Changes
(B = every other year)

INSPECTIONS AT SCHEDULE 1 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
SCHEDULE 1					
INITIAL INSPECTION	6	8	10	18	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTION	2	2	8	10	B

INSPECTIONS AT SCHEDULE 2 FACILITIES

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL VISIT	6	4	10	14	2
INITIAL INSPECTION	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	6	2	8	10	B

AD HOC INSPECTIONS

ACTIVITY	PERSONNEL	TIME-ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
• VERIFY NON-MISUSE OF CW CAPABLE EQUIPMENT	4	1	3	4	600/YR

8. Cost Case 7: Base Case with Biennial Routine Inspections and 300 Ad Hoc Inspections

International cost: $539 million for 15 years
Cost to US: $225 million for 15 years

Case 7 decreases routine inspections to every other year and reduces the number of ad hoc inspections from 600 to 300 a year. Annual US costs for Case 7 are compared with costs for the base case in Figure III-10.

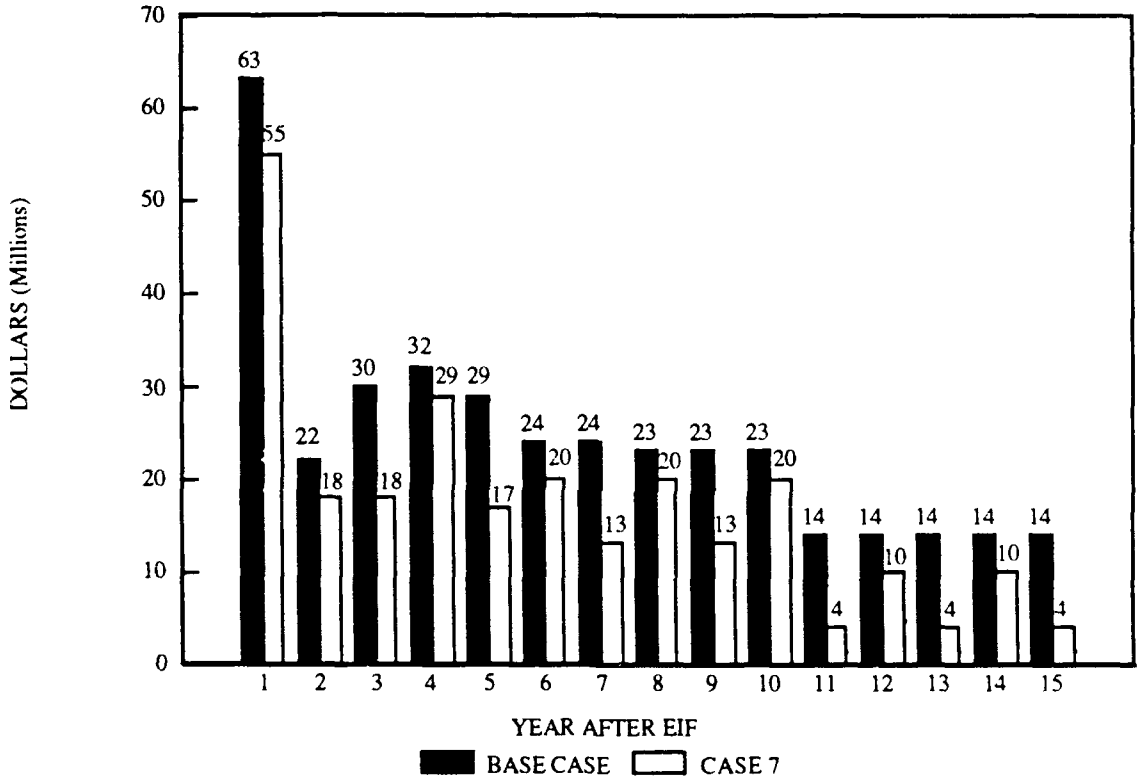

Figure III-10. Case 7 (Biennial Routine Inspections and Halved Ad Hoc Inspections) vs. Base Case: US Costs, Escorts Included

Table III-17. Case 7 Input Changes

AD HOC INSPECTIONS	
United States/NA+SA	8 5
Eastern Europe/USSR	8 5
Western Europe	8 5
Middle East/Africa	2 2
Pacific/Asia	2 3

9. Cost Case 8: Presentation to the Conference on Disarmament
International Cost: $1771 million for 15 years
Cost to the US: $759 million for 15 years

This example is taken from a presentation to the Conference on Disarmament in June of 1989 by Dr. S. Johan Lundin of the Stockholm International Peace Research Institute. Examples given by Dr. Lundin on the size of inspection teams, the frequency and duration of inspections, and requirements for permanent presence were used as resource estimates for this case. In this example, a large number of facilities have a permanent presence, and inspections at Schedule 1 chemical facilities are increased to three times a year. As Dr. Lundin did not specify inspections for Schedule 2 chemical facilities, we have not included Schedule 2 inspections. Also, the cost of sample analysis is not added. We did, however, add time for inspection team preparation and recovery and installation visits. Facilities were distributed worldwide and travel costs were added. The inputs for this case are depicted on Tables III-18 thru III-22, and the costs are compared with the base case costs in Figure III-11.

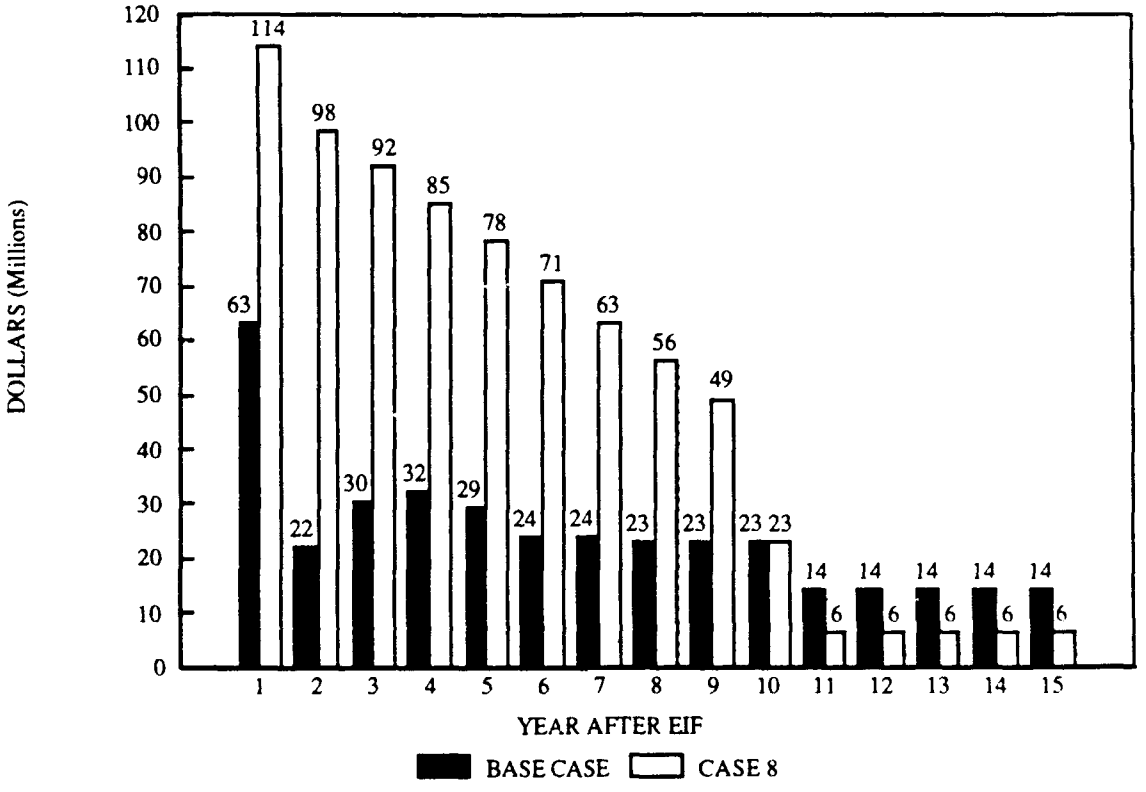

Figure III-11. Case 8 (CD Example) vs. Base Case: US Costs, Escorts Included

Table III-18. Case 8 Storage Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
PERMANENT PRESENCE	9	365	-	365	
INSTALLATION VISIT	5	5	10	15	1

FACILITIES

Year	1	2	3	4	5	6	7	8	9	10
US	10	9	8	7	6	5	4	3	2	1
E. Europe/USSR	10	9	8	7	6	5	4	3	2	1
W. Europe	10	9	8	7	6	5	4	3	2	1
Middle East/Africa	10	9	8	7	6	5	4	3	2	1
Pacific/Asia	10	9	8	7	6	5	4	3	2	1

Table III-19. Case 8 Destruction Facility Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
PERMANENT PRESENCE	10	365	--	365	--
INSTALLATION VISIT	5	5	15	20	1

FACILITIES

Year	1	2	3	4	5	6	7	8	9	10
US	5	5	5	5	5	5	5	5	5	2
E. Europe/USSR	3	3	3	3	3	3	3	3	3	1
W. Europe	3	3	3	3	3	3	3	3	3	1
Middle East/Africa	3	3	3	3	3	3	3	3	3	1
Pacific/Asia	3	3	3	3	3	3	3	3	3	1

Table III-20. Case 8 Production Facilities

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
INITIAL INSPECTION	6	10	10	20	1
CLOSURE INSPECTION (Initial)	6	2	8	10	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	3	2	8	10	1/YR
CLOSEOUT INSPECTIONS	2	1	5	6	1/YR

FACILITIES

Year	1	2	3	4	5	6	7	8	9	10
US	4	4	4	4	4	4	2	2	1	1
E. Europe/USSR	4	4	4	4	4	4	2	2	1	1
W. Europe	4	4	4	4	4	4	2	2	1	1
Middle East/Africa	4	4	4	4	4	4	2	2	1	1
Pacific/Asia	4	4	4	4	4	4	2	2	1	1

Table III-21. Case 8 Schedule 1 Facilities

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
SCHEDULE 1					
INITIAL INSPECTION	4	8	10	18	1
INSTALLATION VISIT	5	5	15	20	1
ROUTINE INSPECTIONS	3	2	8	10	3/YR

FACILITIES

United States/NA+SA	10
Eastern Europe/USSR	10
Western Europe	10
Middle East/Africa	10
Pacific/Asia	10

Table III-22. Case 8 Ad Hoc Inspection Data

INSPECTIONS

ACTIVITY	PERSONNEL	TIME ON-SITE (DAYS)	PREPARATION/ RECOVERY (DAYS)	TOTAL TIME PER OSI/OSV (DAYS)	FREQUENCY
• VERIFY NON-REPORTED PRODUCTION OF SCHEDULE CHEMICALS	4	5	5	10	300 YR

LOCATIONS

United States/NA+SA	100
Eastern Europe/USSR	50
Western Europe	50
Middle East	50
Pacific	50

10. Summary

The fifteen year cost of each case is plotted in Figures III-12 and III-13. Each bar in Figure III-12 represents the annual cost to the US to escort inspection teams in the US and a 40% contribution to the cost of the International Organization. The increment above the base case results shows the magnitude of the estimated capital costs in the previous chapters. These capital costs may be added directly to any of the other examples. The totals for the International Organization are shown in Figure III-13. The breakout of costs to the US by year and inspection type is presented in Figures B-1 thru B-18 in Appendix B. The next section provides a more detailed sensitivity analysis for specific inputs.

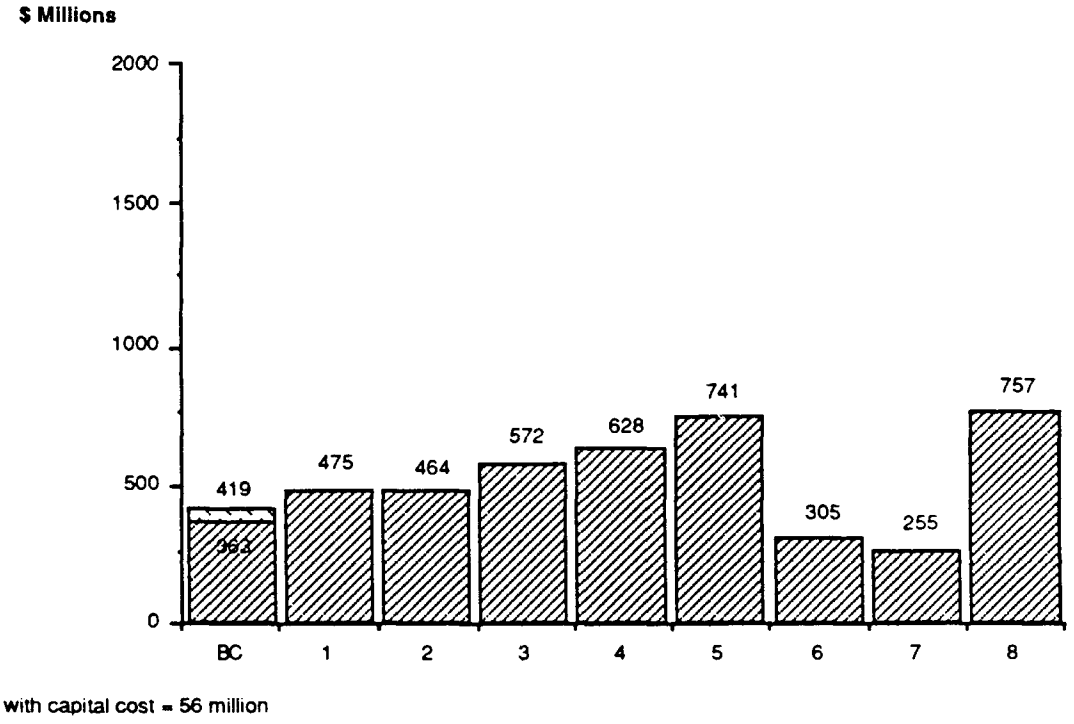

Figure III-12. Summary of Base Case of 8 Alternatives: Cost to the US, Escorts Included

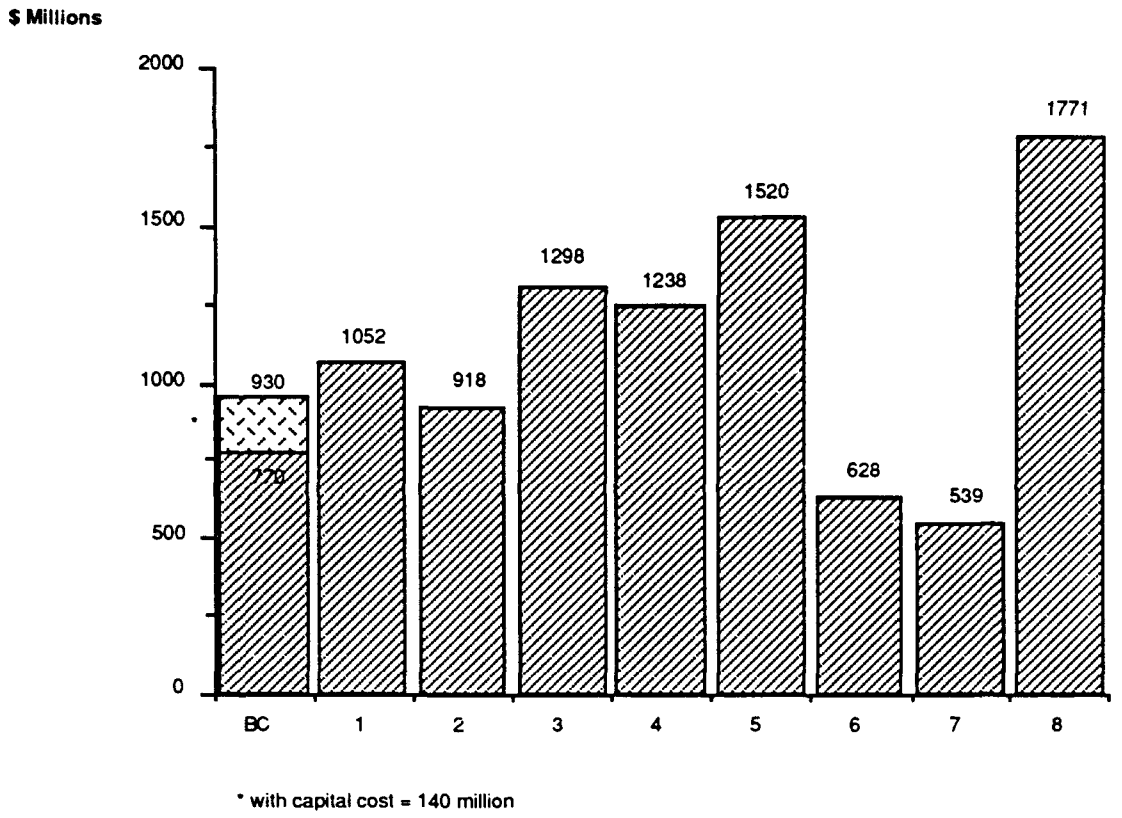

Figure III-13. Summary of Base Case and 8 Alternative Costs to the International Organization

C. SENSITIVITY ANALYSIS

This section displays the sensitivity of various cost factors to total International Organization costs. The International Organization in the base case cost is $770 million for 15 years. This cost total is used for all sensitivity references. Figure III-14 shows the profile of the costs over the period considered.

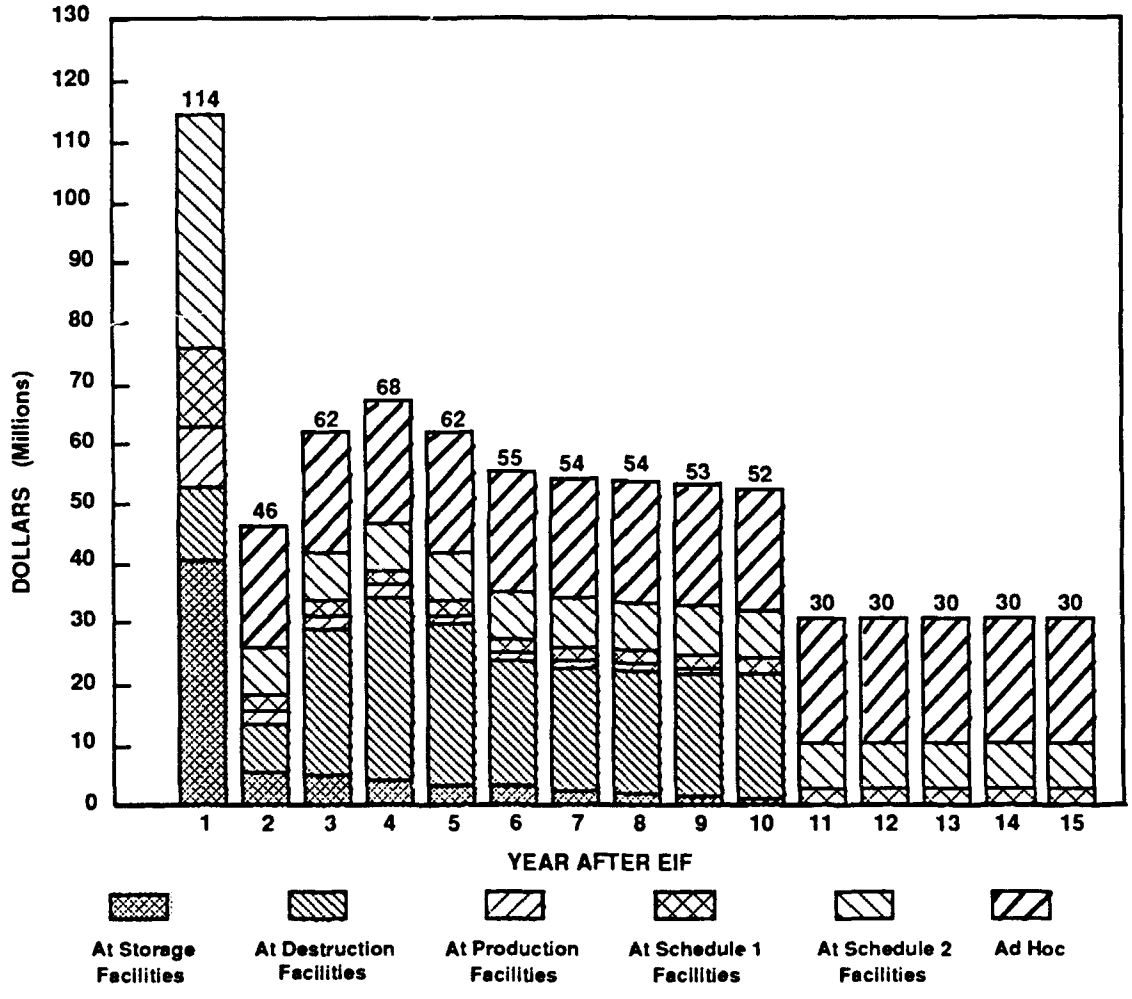

Figure III-14. International Organization Base Case 15-Year Cost: 15-Year Costs = $770 Million

1. Sensitivity of Total Costs to Overhead Factors and Salaries

The base case overhead factor used for the International Organization is three. Figure III-15 displays the effect of variations in overhead and salary levels.

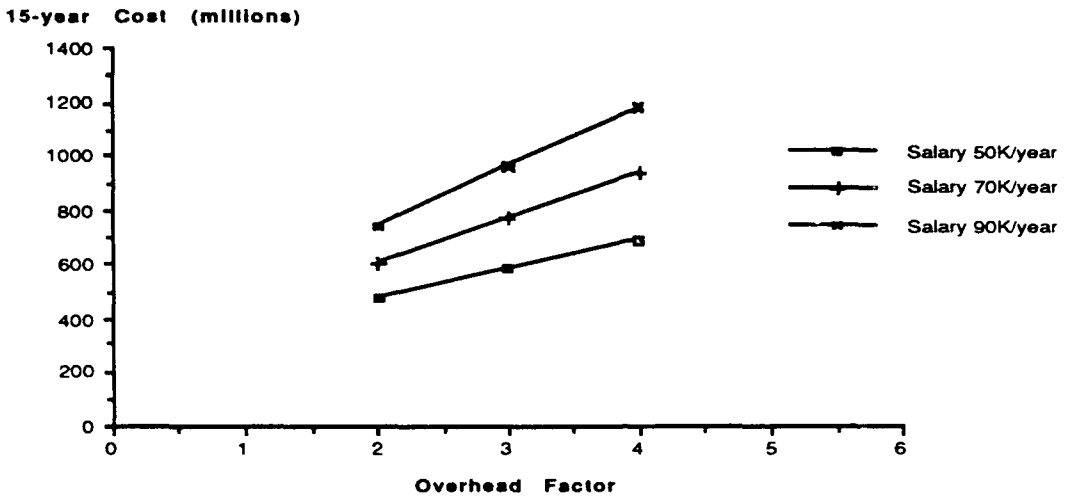

Figure III-15. Sensitivity to Overhead Factor: 15-Year Cost to International Organization

As displayed in Figure III-15, the average salary level assumed for international inspectors has a significant effect on total costs because the number of inspectors is multiplied by the direct labor cost and the overhead factor.

2. Sensitivity to Inspection Team Size

Total costs are affected by varying the size of inspection teams for permanent presence. The base case considers permanent presence to be 365 days at each operational destruction site. The sensitivity of 15-year costs to both the number of inspectors at the facility and the duration of the permanent presence is shown below in Table III-23.

Table III-23. Sensitivity of Permanent Presence

Day of Permanent Presence	Number of Personnel		
	4 (1 Shift)	8 (2 Shift)	12 (3 Shift)
90	$657,562,803	695,335,199	733,107,595
180	$694,606,803	769,423,199	844,239,595
270	$731,650,803	843,511,199	955,371,595
365	$770,752,803	921,715,199	1,072,677,595

3. Sensitivity to the Number of Facilities

The effect of reducing the number of facilities subject to inspection is presented in the following examples. When the number of Schedule 1 chemical facilities is reduced from 36 to 18, as shown in Table III-24, total costs decrease from $770 million to $745 million in the base case. Two examples are given for Schedule 2: Schedule 2 chemical facilities are reduced from the estimate from 70 to 35 in the base case, and then Schedule 2 chemical facilities are doubled from 70 to 140. The distribution input changes are shown in Table III-25. The changes to the 15-year cost are shown in Figure III-16.

Table III-24. Changes to Schedule 1 Chemical Facilities

SCHEDULE 1 FACILITIES		
	BASE	REDUCED
United States/NA+SA	3	1
Eastern Europe/USSR	5	3
Western Europe	8	4
Middle East	10	5
Pacific	10	5

Table III-25. Changes to Schedule 2 Chemical Facilities

DISTRIBUTION OF SCHEDULE 2 FACILITIES			
	35 Total	70 Total	140 Total
United States/NA+SA	10	20	40
Eastern Europe/USSR	10	20	40
Western Europe	10	20	40
Middle East/Africa	3	5	10
Pacific/Asia	2	5	10

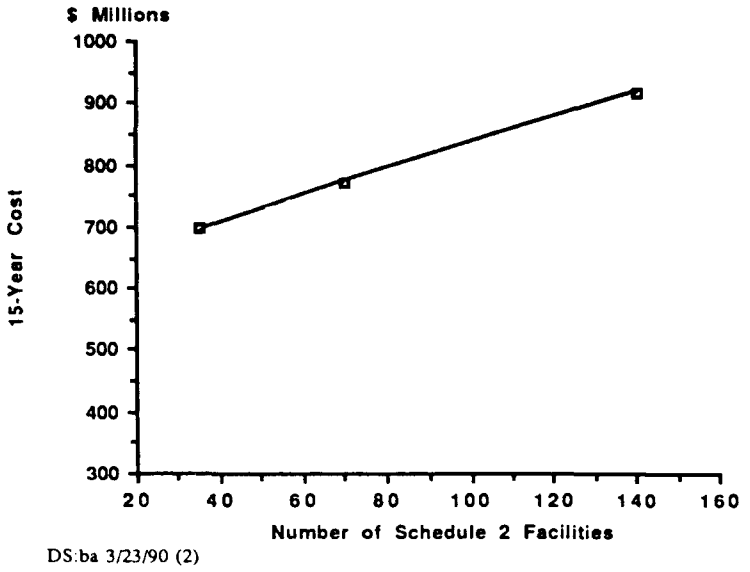

Figure III-16. Sensitivity to the Number of Schedule 2 Chemical Facilities: 15-Year Cost to International Organization

This section shows the effect of variations of a US contribution to the International Organization for the base case. Figure III-17 graphs the percent from 10 to 100. Escort and capital costs are not included.

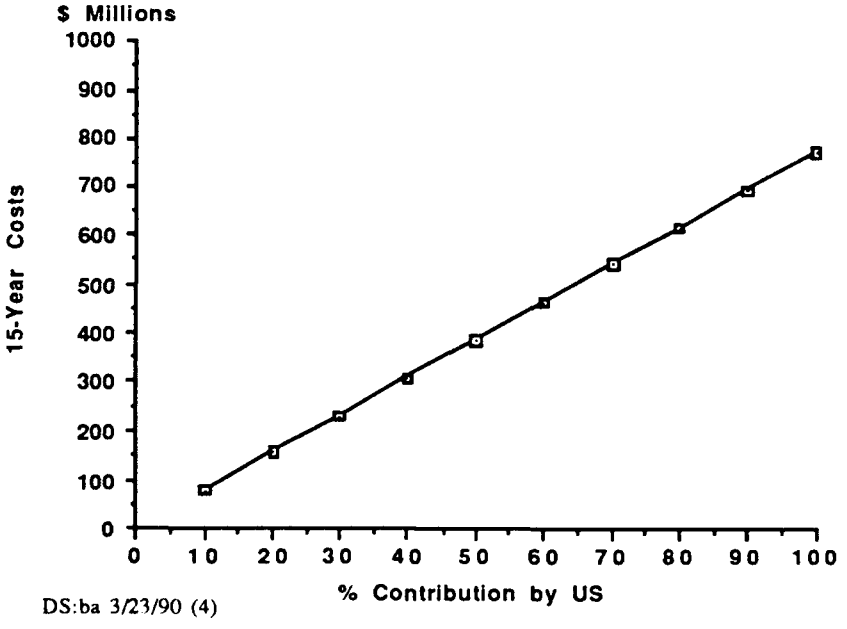

Figure III-17. Sensitivity of US 15-Year Costs to US Contribution to International Organization for Base Case

IV. CONCLUDING REMARKS

A. LIMITATIONS OF THE ANALYSIS

The objective of this task was to design an analytical framework with which to estimate the costs of the draft Chemical Weapons Convention. Although this objective has been accomplished, there are certain limitations in our coverage of verification costs for a final Convention. The foregoing analysis is limited by the tentative nature of many issues for agreement on a final verification regime, the imprecision of the existing language used in the draft Convention, the difficulty of obtaining firm data estimates, and, to some extent, simplifications that are intrinsic to the cost model.

Verification requirements are typically characterized under broad scenarios such as "monitoring stockpiles" and "verifying declarations." Because this approach lacks the necessary precision to identify discrete actions and their associated cost elements, it was necessary to construct a framework. The framework then linked verification objectives directly to inspection team tasks, which describe an inspection or visit, and to more specific actions such as travel to inspection sites. In our effort to define the inspection regime, we have attempted to stay within the intent of the Convention and further compensated for the uncertainty by treating estimates as variable inputs to a cost model.

Nonetheless, the uncertain status of several issues and the time available precluded cost development in some areas. Under some circumstances, these costs may contribute substantially to the total cost of a final regime. Notable examples are the exclusion from this paper of cost estimates for challenge inspections and additional on-site verification activities. In addition, the costs of establishing a Preparatory Commission to train inspection teams may require annual funding of several million dollars. Also, the Convention will mandate an ongoing data review process for the International Organization, and our estimated overhead factor may be insufficient to capture the complete costs of implementing this verification requirement.

The US also will incur costs to create a National Authority responsible for a broad range of domestic implementation measures.[1] Exploration of this issue shows that the US

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[1]CD/961, Article VII, *National Implementation Measures*, page 22.

will need to identify how this National Authority will be organized and whether it is to be established as a new bureaucracy or created as a focal point under existing agencies. Demonstrating compliance with the Convention will in any case require the compilation and dissemination of an extensive amount of data that presently cuts across the jurisdiction of several agencies.

This paper has focused primarily on costs to support an international inspection regime; costs to protect sensitive US facilities and the regulatory burden on domestic industry have not been developed. Industry data from the National Trial Inspections has indicated, however, that industry cost to both prepare for and receive these trial inspections would range between $10,000 and $35,000. There are no current plans for the US government to assume these costs.

Considerable cost also will accrue to destroy binary chemical weapon stockpiles and production facilities. Neither these costs nor the costs of destroying unitary chemical weapons (the latter action having been mandated by Congress) have been included in this paper. It remains to be determined whether the binary destruction cost is attributable to the cost of the Chemical Weapons Convention, although the unitary demilitarization program involves considerable expense which may also apply to a binary destruction program.

The computational methods used could, with rather straightforward modification, accommodate more specific estimates for individual components. As currently calculated, the verification costs do not adequately capture the close-out costs of storage, production, and destruction facilities and the costs of initial inspections at destruction facilities that become operational beyond the first year. As a result, a small portion of the inspection effort is underestimated. Also, more facilities than are accounted for in these estimates may require an on-site inspector presence for longer periods. A somewhat more sophisticated accounting method could easily be adopted to cover these costs, however.

Also, while travel costs for inspectors have been accounted for, most intraregional costs and all costs associated with transporting monitoring equipment to sites have not been included in our totals. The intraregional costs need to be addressed by a more detailed examination of the locations of specific facilities, and the transport costs require a more thorough understanding of what types of equipment will be permitted under the Convention. Further refinement of equipment types will then allow some closer approximation of installation costs and follow-on maintenance.

B. OBSERVATIONS

Several observations follow from the analysis and also from discussions held with individuals in the chemical weapons arms control community. First, the anticipated initial visits and initial inspection requirements outlined in the draft yield substantially higher costs in the first year than in subsequent years. Reducing this first-year cost relative to that for subsequent years may allow resources to be used more efficiently but also might impede the Convention's initial goal of establishing an immediate and comprehensive surveillance system.

The objective of this task was not to question underlying rationales behind the negotiating process but to demonstrate their cost implications as an additional basis for judgment. In this respect, the analysis demonstrates that considerable savings result from varying the frequency of inspection, numbers of inspectors per inspection, and duration of inspection. Also, other issues emerge that should be considered to structure the inspection regime to minimize costs while achieving an appropriate level of verification. Perhaps, for example, the National Authorities could organize supporting material for negotiation of facility agreements to minimize requirements on the International Inspectorate. Likewise, requirements for interim permanent presence could be minimized by shortening the time allowed to reach conclusion on facility agreements. Such options should be investigated to design a cost-effective approach to Convention verification methods. This requires that verification objectives be addressed directly with cost considerations in mind.

It is expected that experience gained from the National Trial Inspections and from implementation of the separate US and USSR bilateral agreements will further expose resource requirements. Consequently, cost estimates can be substantially improved to enhance the structuring of the international and national implementing organizations and general planning for the CWC.

Appendix A

COST EQUATIONS

COST EQUATIONS

This appendix presents the equations used to compute the costs presented in this paper. The three main components of cost are

IC(t) = inspection costs for year t,

TC(t) = travel costs to conduct inspections in year t, and

EC(t) = escort costs for inspections in the US in year t.

Indices are as follows. Index j ranges over the types of facilities:

j = 1 : storage facilities

j = 2 : destruction facilities

j = 3 : CW production facilities

j = 4 : schedule 1 facilities

j = 5 : schedule 2 facilities

j = 6 : facilities subject to ad hoc inspections.

Indices i(j) range over the types of inspection activities at a facility of type j. See Chapter I for this information. Index k ranges over geographical regions:

k = 1 : US (including all of Americas)

k = 2 : Eastern Europe (including USSR)

k = 3 : Western Europe

k = 4 : Middle East

k = 5 : Pacific nations.

INSPECTION COSTS

$$IC(t) = \sum_{j} \sum_{i(j)} \left\{ n_{ij}(t) \left[\sum_{k} f_{jk}(t) \right] \cdot \left(m_{ij}\, d_{ij} \cdot \frac{c^m}{200} \cdot o^I + s_{ij}\, c^s \right) \cdot p \right\}$$

where

$n_{ij}(t)$ = the number of inspections of type i(j) at facility type j during year t

$f_{jk}(t)$ = the number of facilities of type j in region k in year t

m_{ij} = the number of inspectors required to conduct an inspection of type i(j) at a facility of type j.

d_{ij} = the duration (in days) of an inspection of type i(j) at a facility of type j (including preparation and recovery time).

c^m = the direct yearly cost of an inspector

o^I = an overhead factor for the International Organization.

s_{ij} = the number of samples taken during an inspection of type i(j) at a facility of type j

c^s = cost per sample

p = the fraction of International Organization costs to be paid by the US.

TRAVEL COSTS

$$TC(t) = \sum_{j} \sum_{i(j)} \left\{ n_{ij}(t) \left[\sum_{k} f_{jk}(t) \right] m_{ij}\, c^t_k\, p \right\}$$

where $n_{ij}(t)$, $f_{jk}(t)$, m_{ij}, and p are as above and

c^t_k = the commercial round trip air fare between Geneva and region k.

ESCORT COSTS

$$EC(t) = \sum_{j} \sum_{i(j)} \left\{ n_{ij}(t)\ f_{jl}(t)\, c^e_{ij}\, o^u \right\}$$

where $n_{ij}(t)$ and $f_{jl}(t)$ are as above (note: k = 1 signifies the US), and

c^e_{ij} = escort costs for an inspection of type i(j) at a facility of type j

o^u = an overhead factor for escort costs.

Appendix B

GRAPHIC SUMMARIES OF COST CASES

GRAPHIC SUMMARIES OF COST CASES

This appendix contains detailed graphical summaries of the US costs for each case. A chart of the International Organization costs also is included for each case.

The histograms detailing US costs depict the cost as described in Chapters I, II and III. Each histogram represents the annual cost to the US by facility type, i.e., storage, destruction, etc. Escort costs are included in US costs. Using the data and assumptions presented previously, the effect of capitalization may be illustrated by adding $42 million to the respective US cases.

International Organization costs are shown as a histogram of annual costs. The annual costs are not broken out as to source. The International Organization costs of each case are compared to the base case. The effect of capitalization may be illustrated by adding $107 million to the respective International Organization cases.

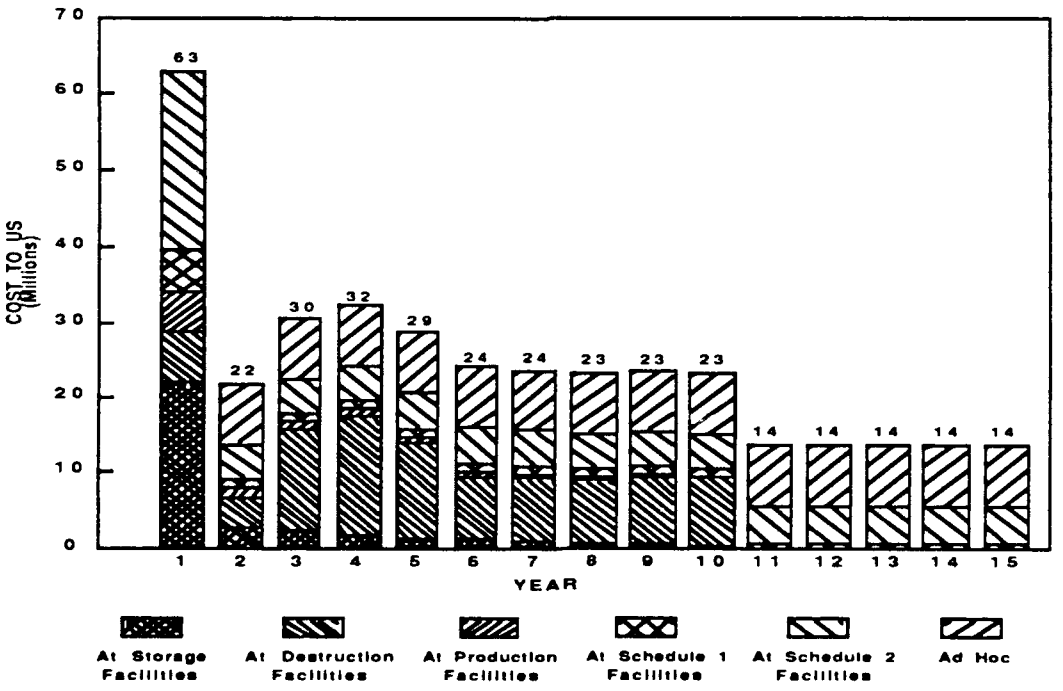

Figure B-1. US Base Case Cost Profile: 15-Year Cost to US = $363M

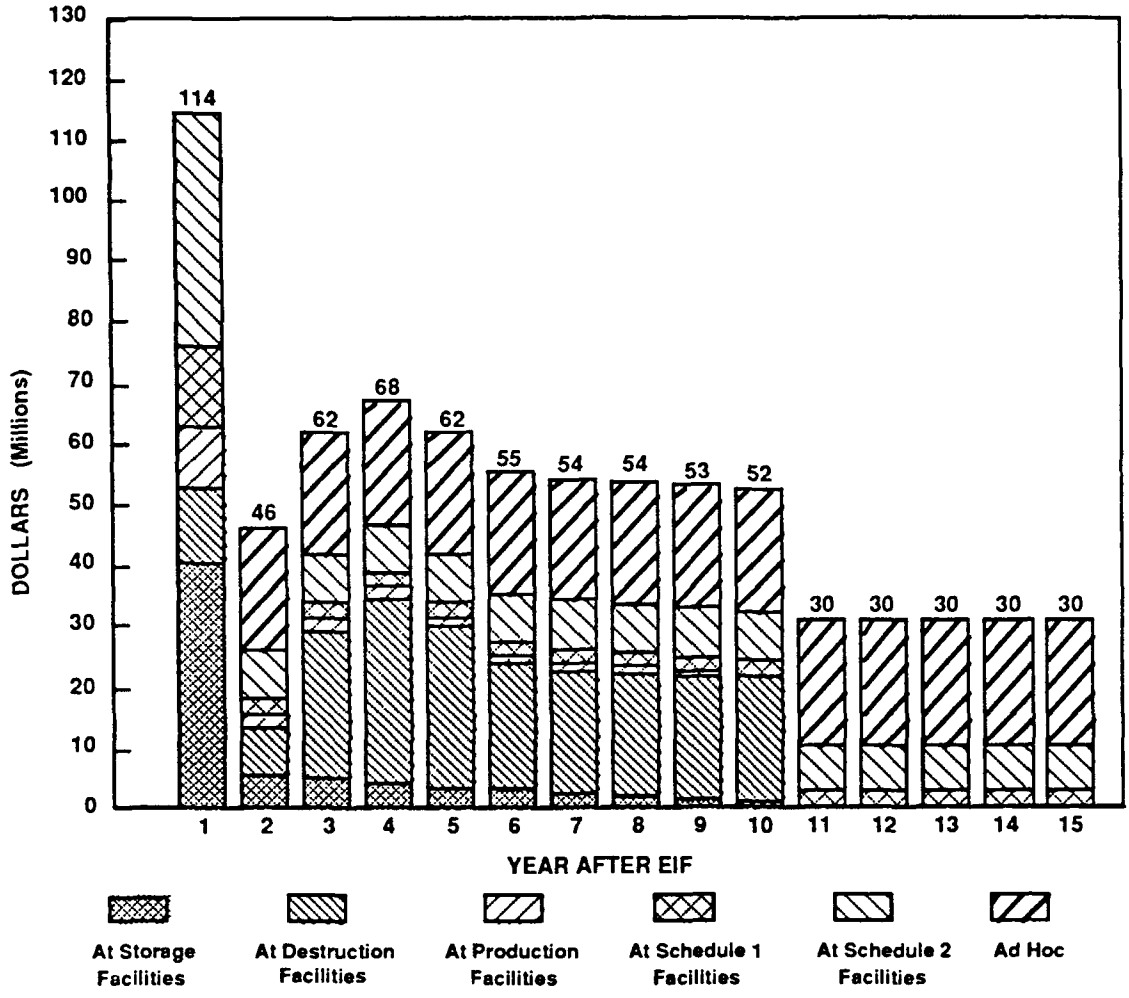

Figure B-2. International Organization Base Case: 15-Year Cost to US = $770M

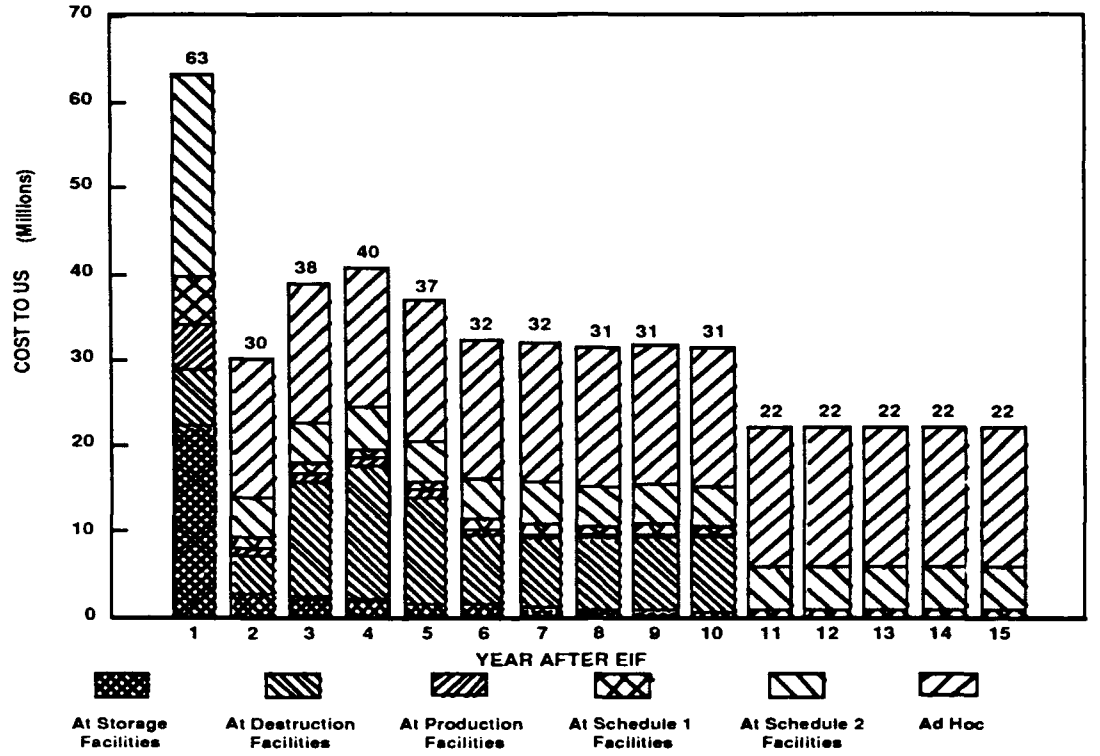

Figure B-3. Case 1: US Base Case With 1,200 Ad Hoc Inspections: 15-Year Cost to US = $475M

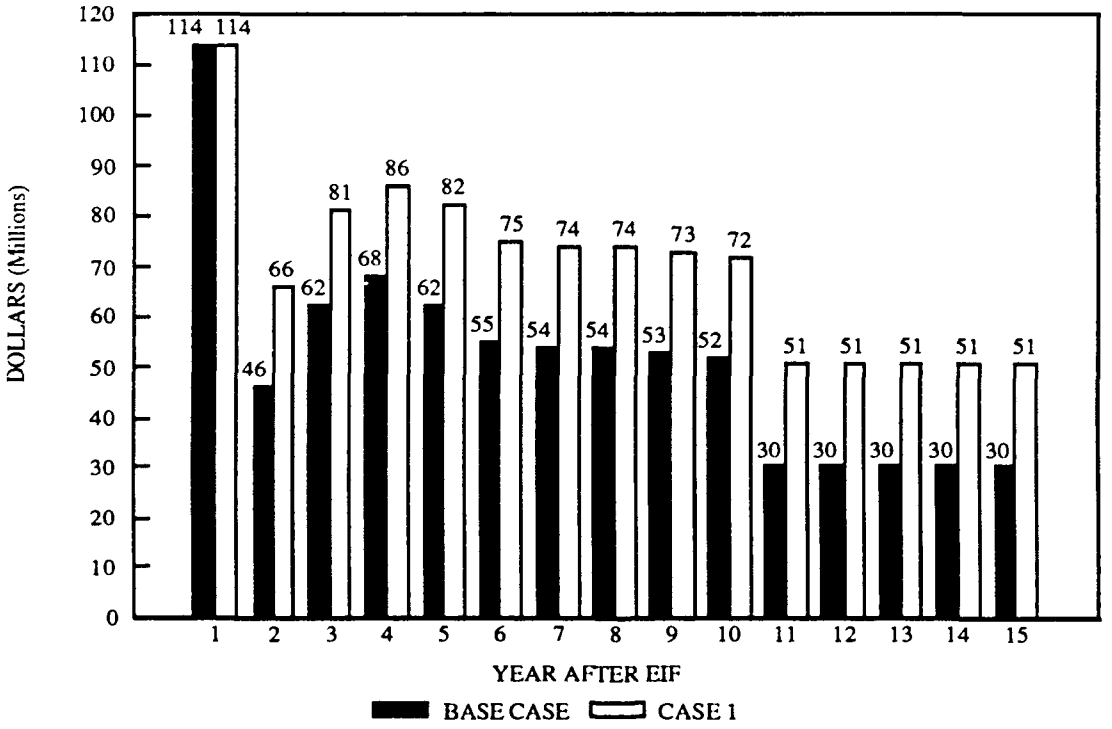

Figure B-4. International Organization Case 1 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $1,052M

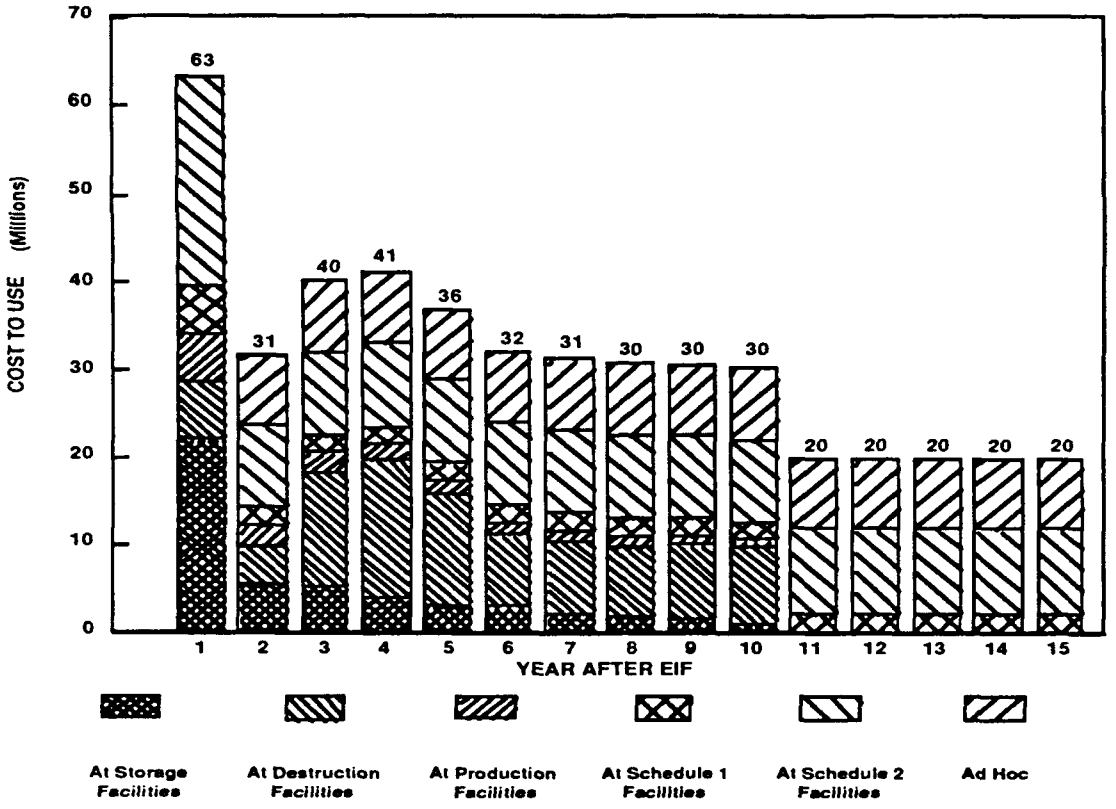

Figure B-5. Case 2: Base Case With Doubled Routine Inspections: 15-Year Cost to US = $464M

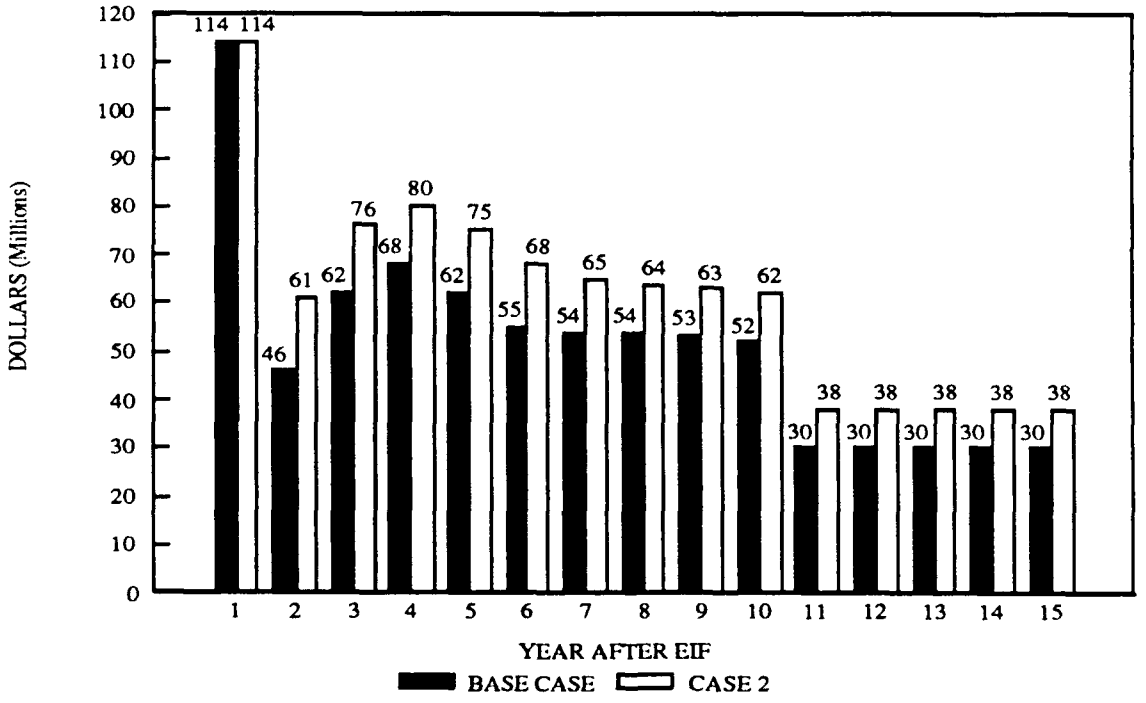

Figure B-6. International Organization Case 2 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $918M

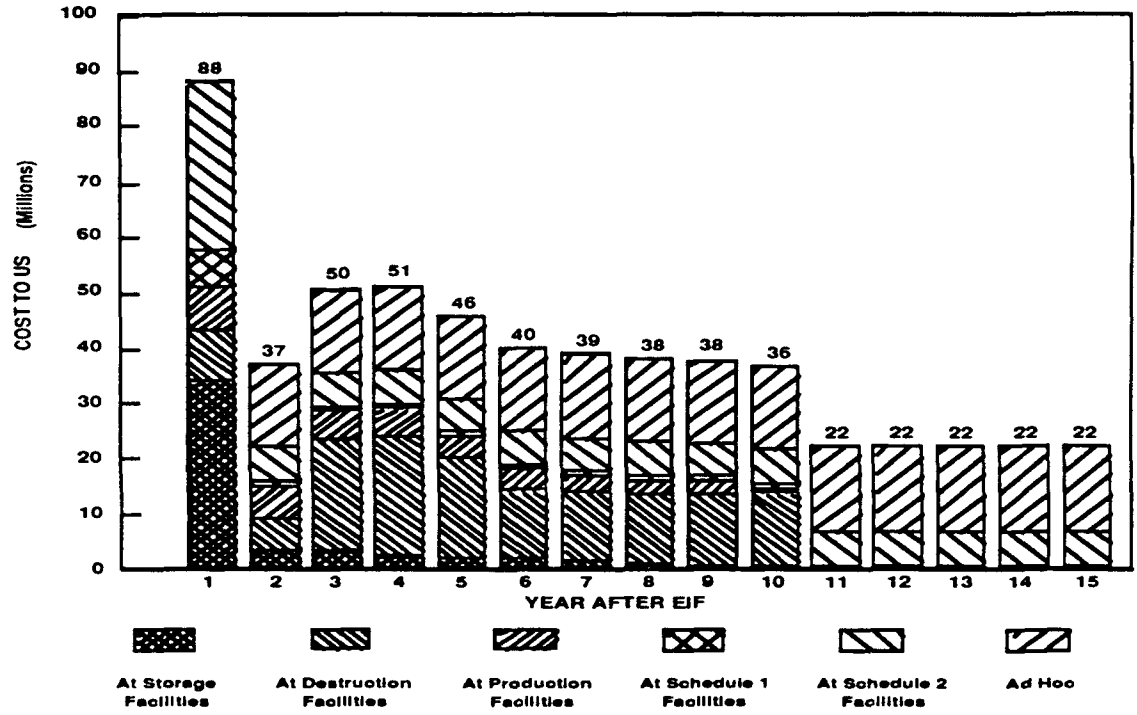

Figure B-7. Case 3: Large Inspection Team Size: 15-Year Cost to US = $572M

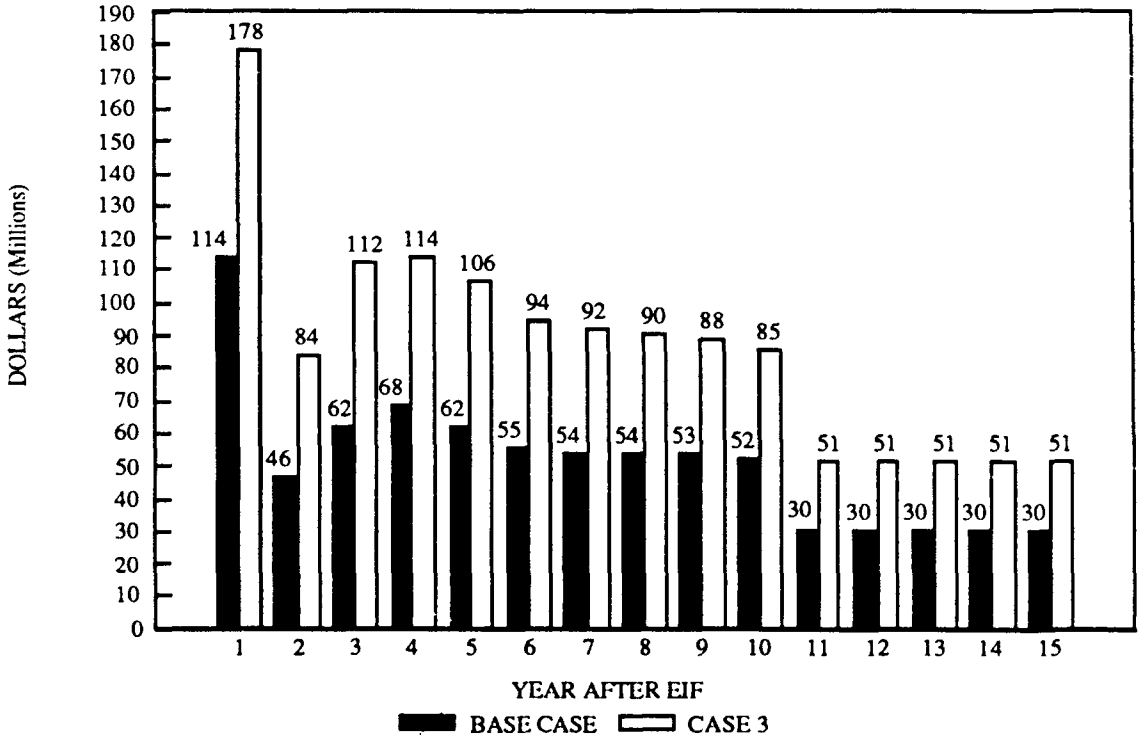

Figure B-8. International Organization Case 3 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $1,298M

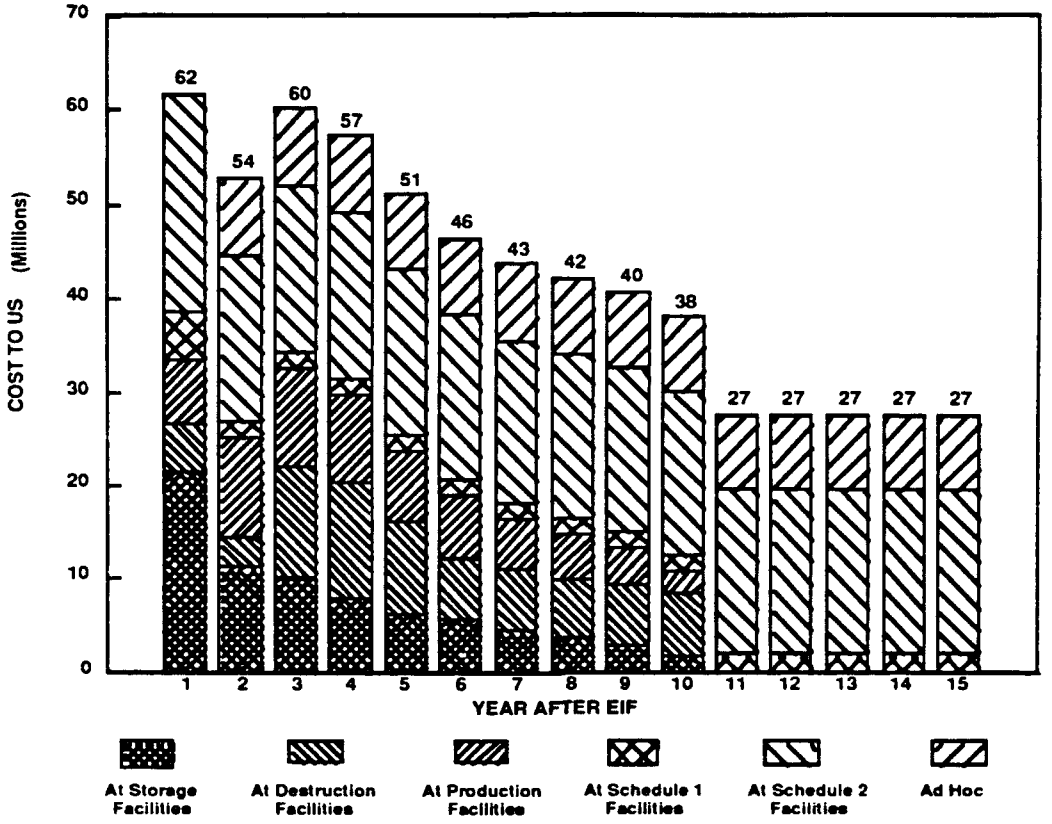

Figure B-9. Case 4: Quarterly Routine Inspections: 15-Year Cost to US = $628M

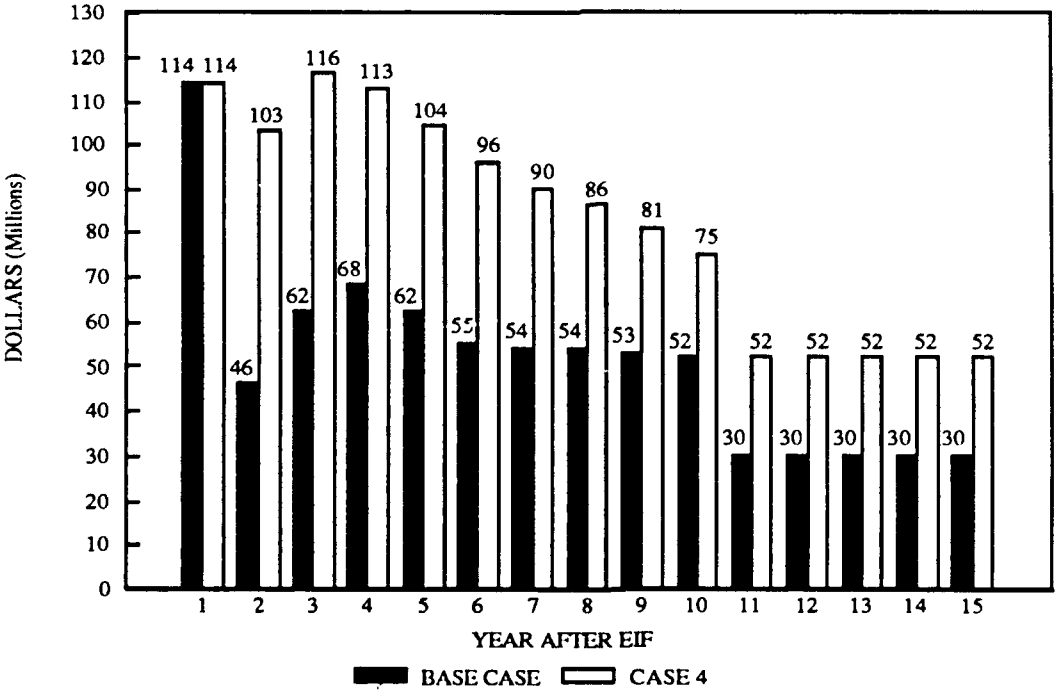

Figure B-10. International Organization Case 4 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $1,238M

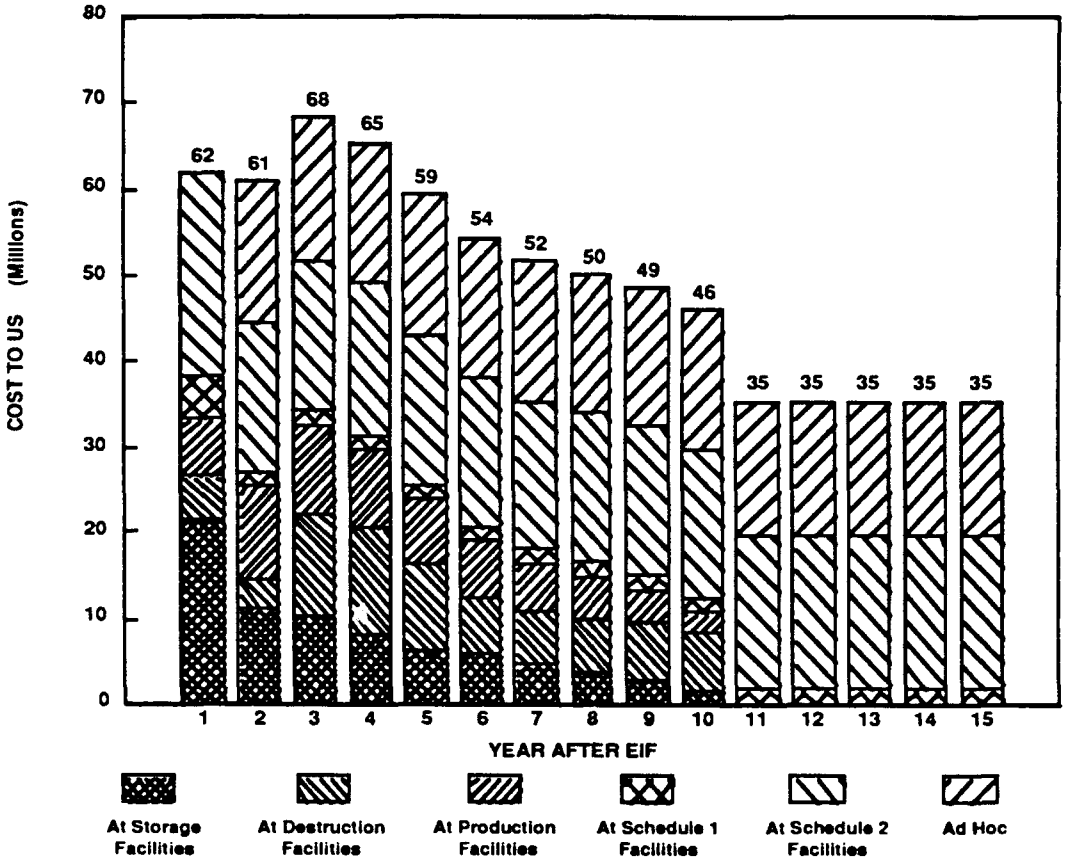

Figure B-11. Case 5: Quarterly Routine Inspections Plus 1200 Ad Hoc Inspections: 15-Year Cost to US = $741M

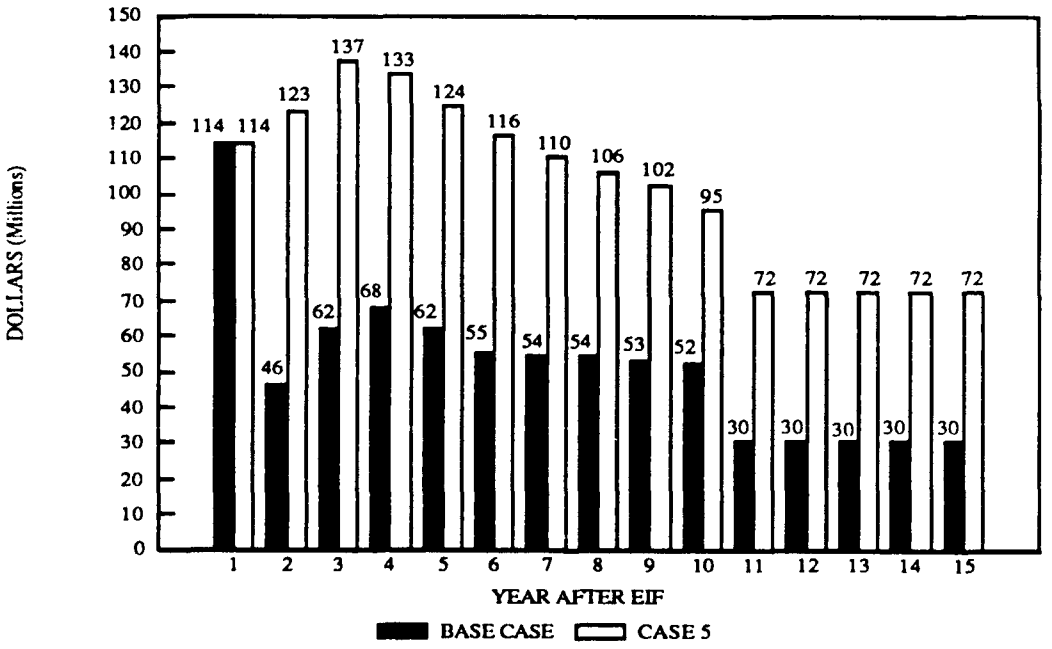

Figure B-12. International Organization Case 5 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $1,520M

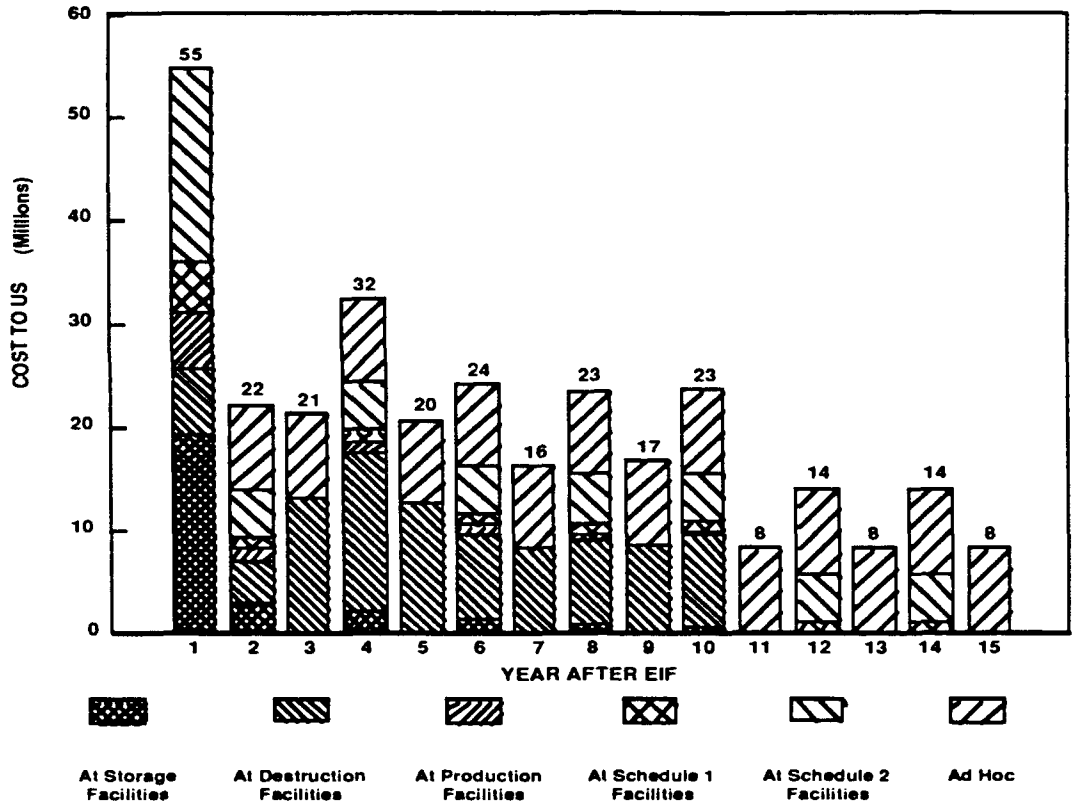

Figure B-13. Case 6: Biennial Routine Inspections: 15-Year Cost to US = $305M

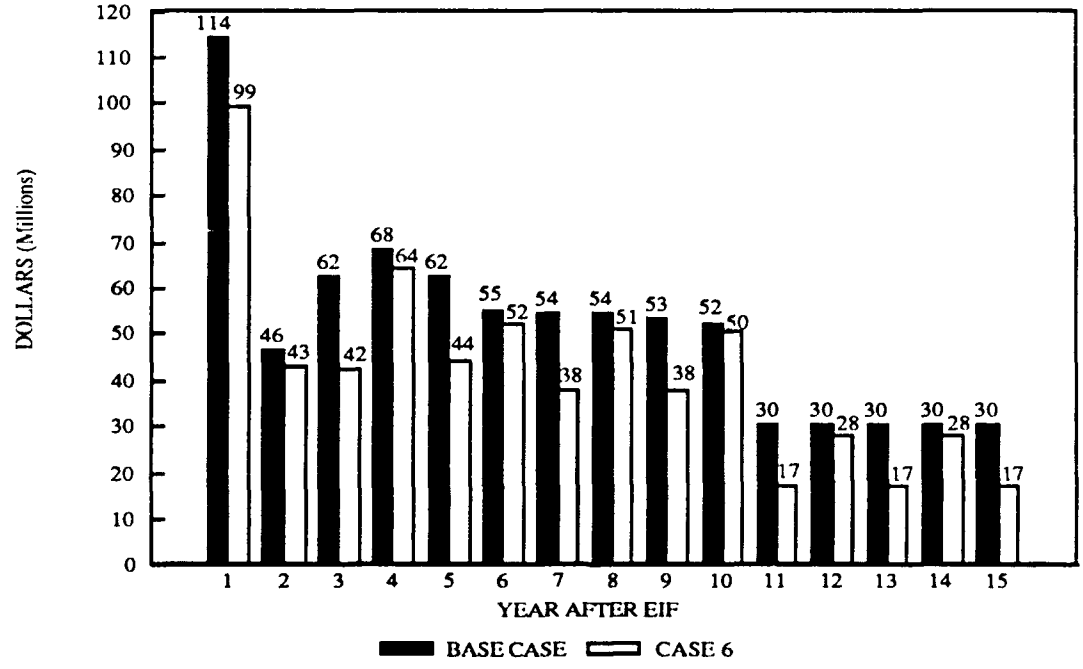

Figure B-14. International Organization Case 6 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $628M

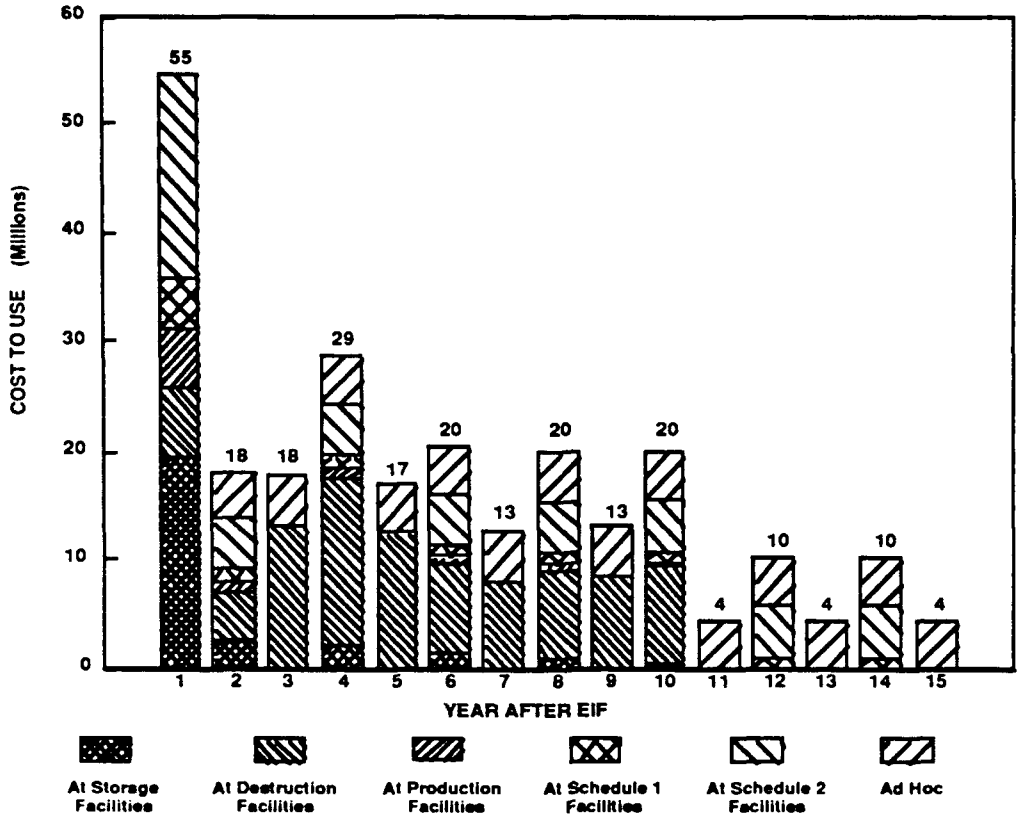

Figure B-15. Case 7: Biennial Routine Inspections and 300 Ad Hoc Inspections: 15-Year Cost to US = $255M

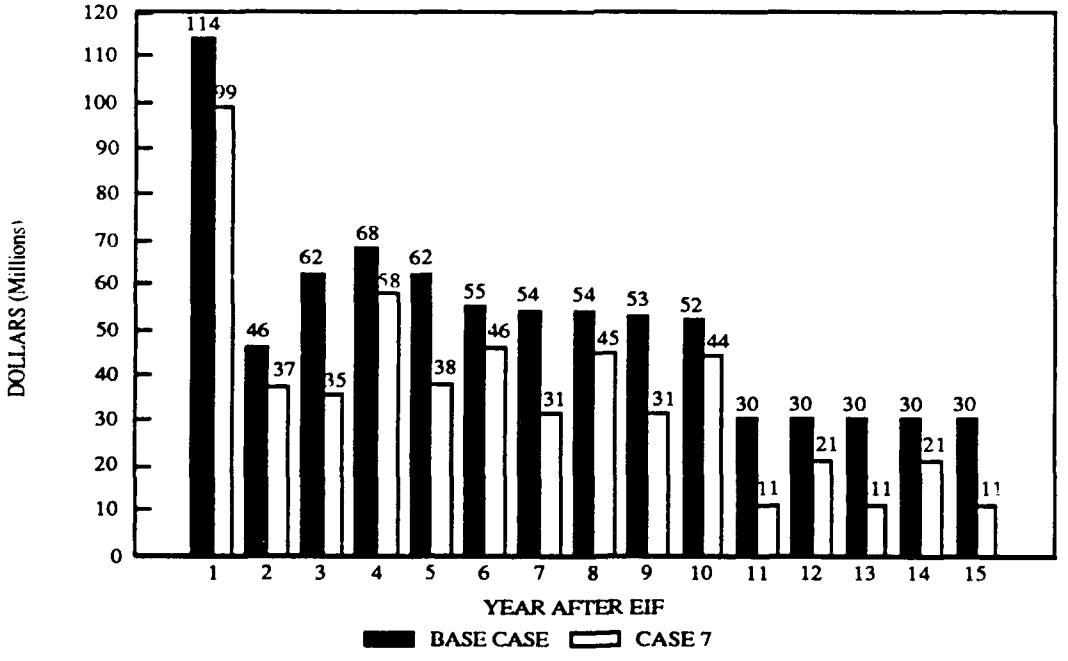

Figure B-16. International Organization Case 7 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $539M

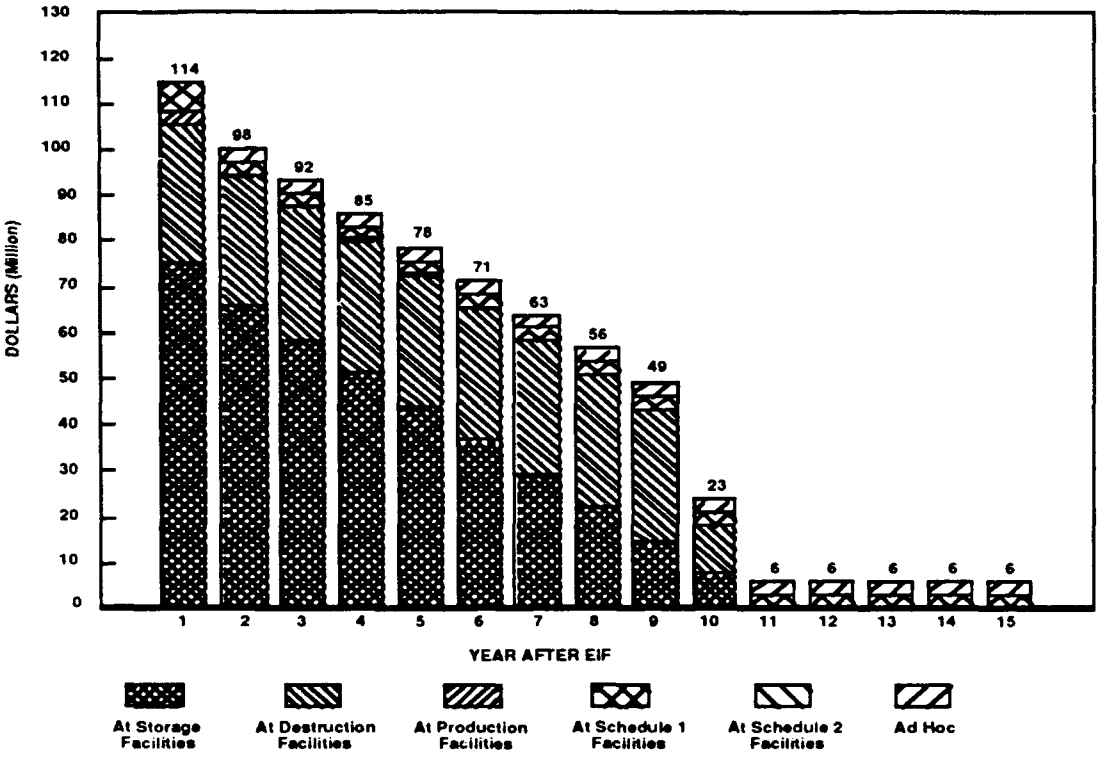

Figure B-17. Case 8: An Example From the Conference on Disarmament: 15-Year Cost to US = $759M

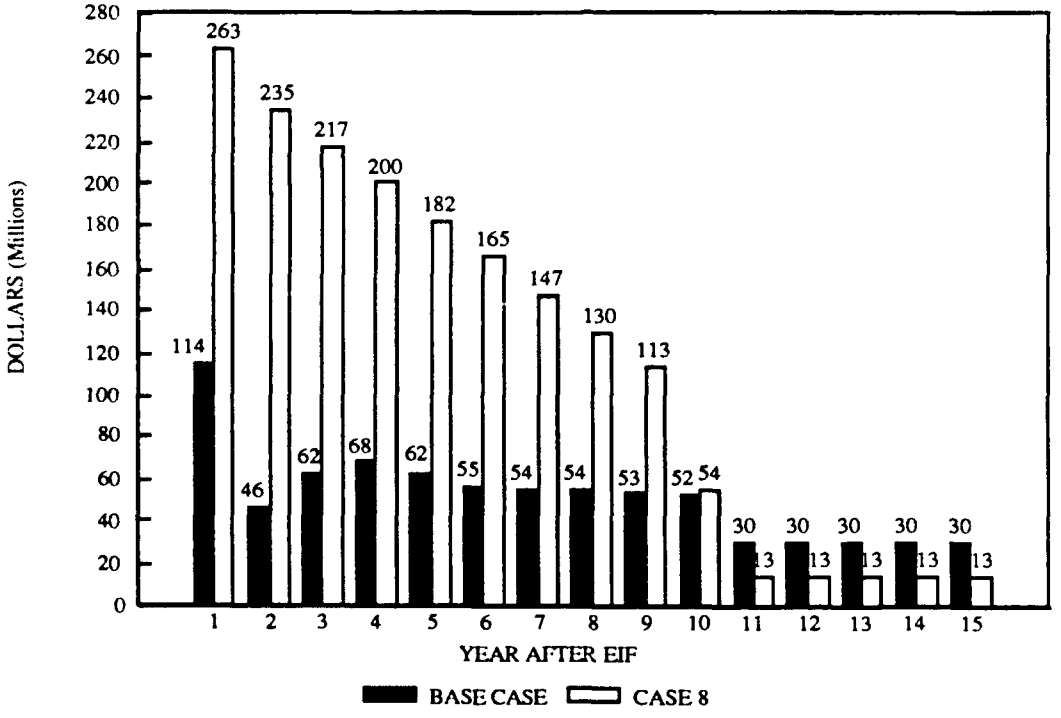

Figure B-18. International Organization Case 8 Cost vs. International Organization Base Case: 15-Year International Organization Cost = $1,771M